UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

FEB 14 2007

In response refer to:
2006/06466

Kevin J. Roukey
Chief, Central California/Nevada Section
U.S. Army Engineer District, Sacramento
1325 J Street
Sacramento, California 95814-2922

Dear Mr. Roukey:

This document transmits NOAA's National Marine Fisheries Service's (NMFS) biological opinion (Enclosure 1) based on our review of the proposed Brannan-Andrus Levee Maintenance District (BALMD) 13 PL 84-99 Levee Repairs, and their effects on Federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened Central Valley steelhead (*O. mykiss*), and their designated critical habitat in accordance with section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). This biological opinion also includes a section 7(a) (2) analysis of project related effects on the threatened Southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*).

The proposed levee repairs are being performed pursuant to Governor Schwarzenegger's February 24, 2006, emergency proclamation for California's levee system. The Governor's proclamation ordered the emergency repair of levees to prevent the imminent loss of human property and life. The Governor later signed Executive Order S-18-06, directing the California Department of Water Resources to identify and repair eroded levee sites on the State/Federal levee system to prevent catastrophic flooding and loss of life. The 13 sites identified in the BALMD are eligible for Public Law (PL) PL 84-99 Rehabilitation Assistance and are part of the State of California's highest priority for emergency repairs (BALMD 2006).

The levee repairs would be performed by BALMD under permit from the U.S. Army Corps of Engineers (Corps). Your request for formal consultation was received on December 6, 2006. Because of the imminent threat to human life and property, the Corps proposed an Action Plan and Alternative Consultation Procedure to expedite the design, environmental review, and construction of these sites while avoiding an irreversible or irretrievable commitment of resources, pursuant to section 7(d) of the ESA. The Corps' proposed Action Plan and Alternative Consultation Procedures were developed to provide NMFS with the information necessary to complete the ESA section 7 consultation and Magnuson-Stevens Conservation and Management Act (MSA) Essential Fish Habitat (EFH) consultation, concurrent with the levee repair actions. Therefore, NMFS initiated formal consultation on December 13, 2006.

This biological opinion is based on information provided in the November 2006, *Brannan-Andrus Levee Maintenance District 13 PL 84-99 Emergency Repair Sites Sacramento County, California Biological Assessment, and the November 2006 Evaluation of the Brannan-Andrus Levee Maintenance District 13 PL 84-99 Emergency Repair Sites Using the Standard Assessment Method.* The biological opinion also is based on design drawings for each of the 13 projects, information provided at Collaborative Flood Maintenance Program meetings, site visits and discussions held with representatives of NMFS, U.S. Fish and Wildlife Service, the California Department of Fish and Game, the Corps, BALMD, and Tetra Tech, Inc. A complete administrative record of this consultation is on file at the NMFS Sacramento Field Office.

Based on the best available scientific and commercial information, the biological opinion concludes that these projects are not likely to jeopardize the above species or adversely modify designated critical habitat. NMFS has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to minimize incidental take associated with project actions. The listing of the Southern DPS of North American green sturgeon became effective on July 7, 2006, and some or all of the ESA section 9(a)(1) prohibitions against take will become effective upon the future issuance of protective regulations under section 4(d). Because there are no section 9(a)(1) prohibitions at this time, the incidental take statement, as it pertains to the Southern DPS of North American green sturgeon does not become effective until the issuance of a final 4(d) regulation, as appropriate.

Also enclosed are draft EFH Conservation Recommendations for Pacific salmon as required by the MSA as amended (16 U.S.C. 1801 *et seq.*; Enclosure 2). This document concludes that the BALMD 13 Emergency Levee Repairs will adversely affect the EFH of Pacific Salmon in the action area and adopts certain of the terms and conditions of the incidental take statement and the ESA Conservation Recommendations of the biological opinion as the EFH Conservation Recommendations.

Section 305(b)4(B) of the MSA requires that the Corps provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the Corps for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR 600.920[j]). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

If you have any questions regarding this correspondence please contact Mr. William Leet in our Sacramento Area Office, 650 Capitol Mall, Suite 8-300, Sacramento, California 95814. Mr. Leet may be reached by telephone at (916) 930-3608 or by Fax at (916) 930-3629.

Sincerely,

Rodney R. McInnis
Regional Administrator

Enclosures (2)

cc: Copy to file: 151422SWR2006SA00718
NMFS-PRD, Long Beach, CA
General Manager, The Reclamation Board, 1416 9th Street Sacramento, CA 95833
Doug Weinrich, USFWS, 2800 Cottage Way, Sacramento, CA 95825
Gary Hobgood, CDFG, 1701 Nimbus Road, Suite A, Rancho Cordova, CA 95670
David Lundgren, Tetra Tech, 180 Howard Sreet, Suite 250, San Francisco, CA 94105
Gilbert Labrie, BALMD, P.O. Box 929, Walnut Grove, CA 95690
Liz Holland, U.S. Army Corps of Engineers, 1325 J Street, Sacramento, CA 95814-2922

Enclosure 1

BIOLOGICAL OPINION

ACTION AGENCY:	United States Army Corps of Engineers Sacramento District
ACTIVITY:	Brannan-Andrus Levee Maintenance District, 13 PL 84-99 Levee Repairs
CONSULTATION CONDUCTED BY:	NOAA's National Marine Fisheries Service, Southwest Region
FILE NUMBER:	151422SWR2005SA00659
DATE ISSUED:	February 19, 2007

I. CONSULTATION HISTORY

February 24, 2006, Governor Arnold Schwarzenegger issued an emergency proclamation for California's levee system. The proclamation focused on the imminent threat of 24 critical levee erosion sites located in Colusa, Sacramento, Solano, Sutter, Yolo, and Yuba counties.

August 25, 2006, the U.S. Army Corps of Engineers (Corps) determined that Public Law (PL) 84-99 Order 1 and 2 sites present an imminent threat to public life and property and authorized immediate emergency levee repair actions.

September 30, 2006, the California Department of Water Resources (CDWR) determined that the Governor's proclamation encompassed PL 84-99 Order 1 and 2 sites and provided state funding to implement their repairs.

October 26, 2006, NOAA's National Marine Fisheries Service (NMFS) staff accompanied CDWR and environmental and engineering consultants (*i.e.*, the URS Corporation, Tetra Tech, and DCC Engineering) for field reviews of CDWR-led sites. NMFS provided consultants a list of bank stabilization design recommendations to minimize impacts to anadromous salmonids.

October 30, 2006, David Lundgren (Tetra Tech) requested information from NMFS on the Standard Assessment Methodology (SAM) model. He was referred to Corps biologist Mike Dietl.

November 15, 2006, An alternative consultation schedule was developed, and David Lundgren advised that NMFS should receive the draft Biological Assessment (BA) for the Brannan-Andrus Levee Maintenance District (BALMD) repair sites on November 20, 2006.

November 16, 2006, Action Plan and Alternative Endangered Species Consultation Procedures for State-Federal Expedited Levee Repair, Brannan-Andrus Levee Maintenance District 13 PL 84-99 Sites issued by the Corps.

November 21, 2006, NMFS staff consulted David Lundgren via telephone regarding aspects of the draft BA for the BALMD repair sites.

November 22, 2006, NMFS received an electronic transmission of the draft BA for the BALMD sites.

November 29, 2006, NMFS advised Tetra Tech staff on interpretation of SAM model.

On January 18, 2007, Tetra Tech provided NMFS with a copy of the final BA and SAM model results

This biological opinion is based on information provided in the BA; discussions held with Tetra Tech, the URS Corporation, the Corps, USFWS, and CDFG; field reviews of the erosion sites, SAM analyses; and engineering designs. A complete administrative record of this consultation is on file at the NMFS Sacramento Area Office.

II. DESCRIPTION OF THE PROPOSED ACTION

As a result of imminent threat of catastrophic levee failure, Governor Arnold Schwarzenegger declared a State of emergency for the California Levee system and ordered the immediate repair of critical levee erosion sites in the Sacramento River Flood Control Project (SRFCP), in Colusa, Sacramento, Solano, Sutter, Yolo, and Yuba counties. The SRFCP consists of approximately 980 miles of levees, plus overflow weirs, pumping plants, and bypass channels that protect urban and agricultural lands in the Sacramento Valley and the Sacramento-San Joaquin River Delta (Delta). The Governor's proclamation ordered the emergency repair of levees to prevent the imminent loss of human property and life. The repairs are being constructed under a variety of Federal and State levee maintenance and repair authorities, including the Sacramento River Bank Protection Project, and PL 84-99. The repairs proposed in this action are authorized under PL 84-99. PL 84-99 is a Federal law that authorizes the Corps to repair or fund the repair of existing flood control works that are damaged from flooding.

The BALMD, through PL 84-99, and under a permit issued by the Corps, will take all necessary actions to stabilize 13 critical levee erosion sites along the Sacramento River, within the BALMD. All the erosion sites are located along the left (L) bank of the river and slough, and are designated by distance in miles from the mouth. The convention for right and left bank designation is "as facing downstream;" thus, RM 10.9L is located 10.9 miles from the mouth, on the left bank as one faces downstream. In addition to RM 10.9L, the sites are located at RM 11.1 L, RM 11.2 L, RM 12.5 L, RM 122.6 L, RM 12.7 L, RM 12.8 L, RM 12.9 L, RM 13.0 L, RM

13.4 L, RM 13.6 L, RM 15.3 L, and RM 15.4 L. Collectively, these erosion sites are referred to as the BALMD PL 84-99 emergency repair sites, or simply the BALMD sites.

The BALMD is authorized and funded by the State of California to design, construct, and maintain levees to protect the town of Isleton, Brannan and Andrus Islands, and Highway 160 from the effects of bank erosion and a breach in the levee system. The BALMD is the project lead and proponent of the proposed action. The levee repair work is administered by BALMD through a permit issued by the Corps as described in the second paragraph under Section II, above.

A. Project Description

The proposed action is to place rock and wood revetments along the waterside slope of each erosion site. The proposed levee repair work is designed to halt erosion, minimize the loss of riparian vegetation and nearshore aquatic habitat resulting from construction activities, prevent the eventual loss of nearshore aquatic habitat and riparian habitat that probably would occur if the project were not constructed, and provide compensation, if needed, for unavoidable impacts to existing riparian habitat and nearshore aquatic habitat. The location of the 13 repair sites is shown Table 1 and in Figures 1, 2, and 3.

Approximately 3,500 linear feet (lf) of levee bank will be repaired under this emergency action using approximately 60,000 cubic yards of quarry stone mix and approximately 15,000 cubic yards of agricultural soils. These materials will be placed from approximately 2 feet below the levee embankment outwards to approximately 75 to 80 feet into the water. The project will inevitably cover some existing riparian, emergent marsh, and shallow water habitats, but these habitats will be established or reestablished in greater quantities than currently present.

The bench or platform design serves several functional roles, including providing an area that can be used for plantings to provide shaded riparian aquatic habitat and aid in reducing flow velocities from wave and wind action. In addition it provides an area to repair existing scour and an area to provide a buffer against toe scour. The bench is also designed to be inundated daily (tidal) to provide shallow water habitat. The lower slopes of the levee benches will be planted with emergent marsh vegetation or riparian vegetation (*i.e.*, willow bundles), depending on the elevation to summer water levels. A rock and agricultural soil mixture will be used mainly in the slopes of the levee. Coir fabric or jute netting will be used to prevent soil loss during the high water periods before most plant species are planted in the spring. The BALMD environmental representative was in coordination with the U.S. Fish and Wildlife Service (USFWS) and NMFS while they determined that the use of instream woody material (IWM) was not beneficial to listed delta smelt (*Hypomesus transpacificus*) at this section of the Sacramento River. The designs, which initially included placement of IWM, were reassessed to remove the IWM, based on the recommendations from the USFW and NMFS. Riparian trees and shrubs will be planted along the upper levee banks in the larger rock voids, and raceme-bundle willow plantings will be made on the lower banks. All trees and shrubs within the sites will be protected to the fullest extent possible through the use of tree wraps and boards, where feasible. Site designs as well as typical cross sections for the emergency repair sites are contained in BALMD 2006.

Construction is proposed to begin as soon as possible, preferably in early February 2007. The construction and repair work is proposed to be completed in two phases, totaling approximately 220 days. The first phase calls for the addition of approximately 53,600 tons of light class rock and 114,400 tons of riprap along the approximate 4,800 feet of levee bank. These materials will be placed from approximately two feet below the levee embankment outwards to approximately 75 to 80 feet into the water. This work is estimated to take 100 days to complete.

The second phase of this project includes the addition of approximately 60,000 cubic yards of quarry stone mix and approximately 15,000 cubic yards of agricultural soils along the levee bank. This phase will also include the restoration of the levee bank and instream habitat by creating benches and planting several plant species along the levee slope and upland area. This phase involves revegetating the project site with native plants and monitoring them for successful establishment and for stream function. This work is estimated to take 120 days to complete and will begin after Phase I, preferably in the spring.

Wherever feasible, construction will be conducted from the waterside of the riverbank through the use of a barge with a long-arm crane. There are a few sites, RM 10.7-11.2 (20051230-039-001 and 20051230-039-002) and RM 13.4-13.6 (20051230-039-010 and 20051230-039-011), where the use of a barge is not feasible due to shallow water or other accessibility issues. In these instances, the contractor will use the turnoffs along Highway 160 to perform the construction. A staging area has been established in the flat grassy area immediately northwest of the intersection of Highway 160 and Highway 12.

Table 1. Site Identification and River Mile

Site Number	Site Identification	River Mile
1	20051230-039-001	10.9
2	20051230-039-002	11.2
3	20051230-039-003	12.5
4	20051230-039-004	12.5
5	20051230-039-005	12.6
6	20051230-039-006	12.7
7	20051230-039-007	12.8
8	20051230-039-008	12.8
9	20051230-039-009	12.9
10	20051230-039-010	13.4
11	20051230-039-011	13.6
12	20051230-039-012	15.3
13	20051230-039-013	15.4

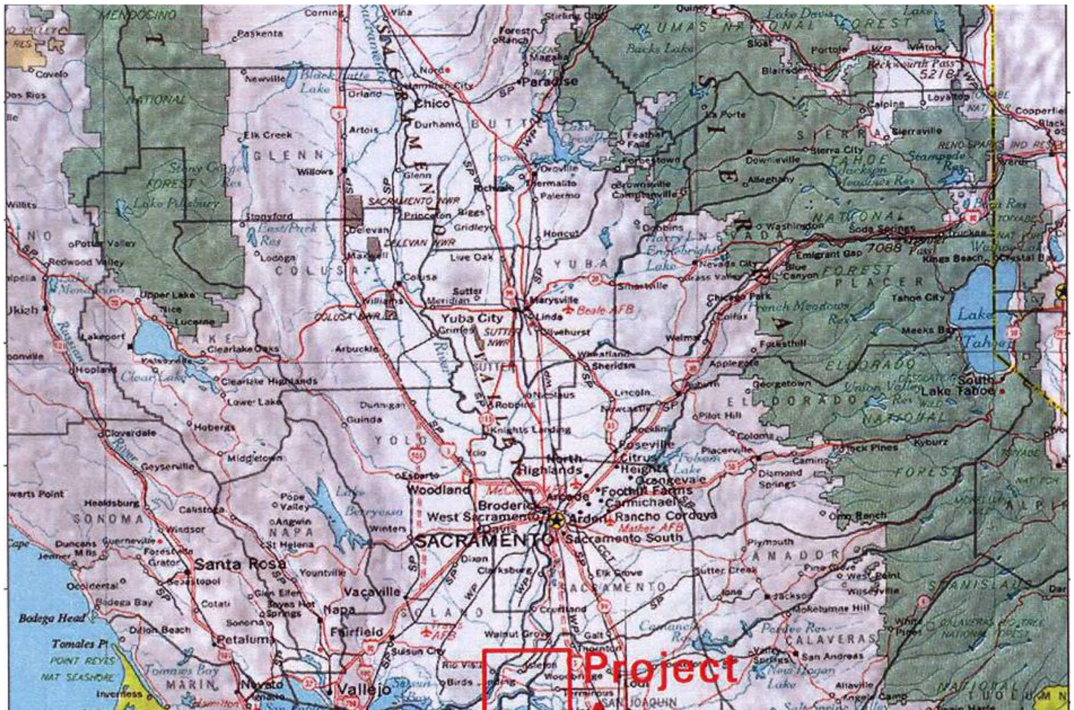

Figure 1. Project area in California.

Figure 2. Aerial photograph of site vicinity.

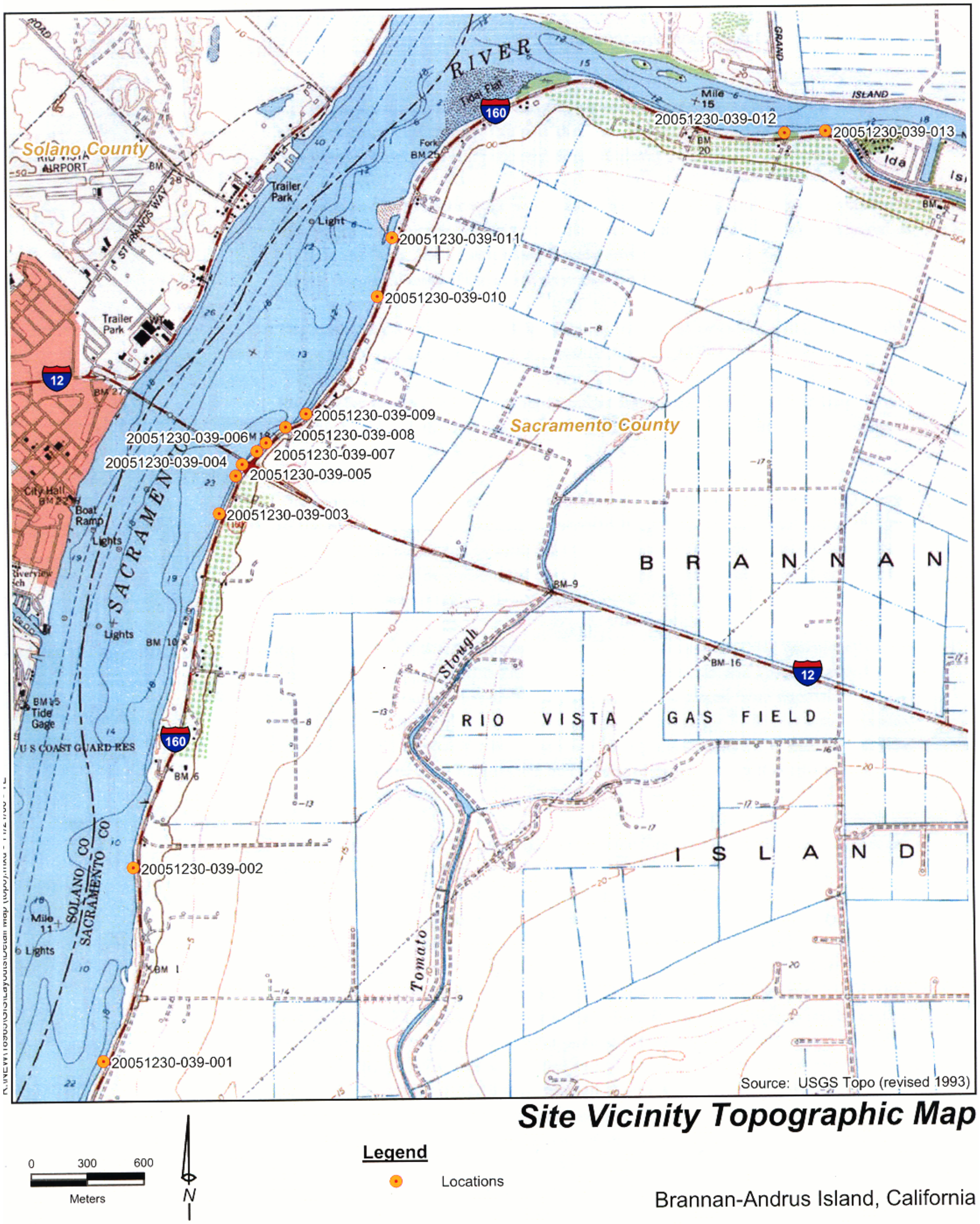

Figure 3. Site vicinity map.

Standing and fallen trees at the project sites would be protected in place to the maximum extent possible, and all disturbed areas would be protected with erosion control measures such as hydro seeding and plug plantings. Where necessary, clearing of smaller vegetation from the levee slope would be accomplished using small equipment and/or hand tools. Some pruning of trees may be required during the construction phase.

Riparian trees and shrubs would be planted along the project sites at elevations extending from near the summer water level, towards the top of the bank. Vegetation generally will be planted on two- to five-foot centers, in three to four zones. Planting zones may include emergent marsh, emergent bench, transition slope, riparian bench, and levee slope. Planting plans vary by site and location of project features in relation to the size and slope of the levee. Plans include red willow (*Salix lasiolepis*), and narrowleaf willow (*Salix exigua*). Large tree species such as oak, sycamore, and cottonwood are not included in some designs because of long-term levee stability concerns. Trees included in the landscaping plans include a diverse assemblage of species including box elder (*Acer negundo*), white alder (*Alnus rhombifolia*), Oregon ash (*Fraxinus latifolia*), Western sycamore (*Platanus racemosa*), Fremont cottonwood (*Populus fremontii*), Valley oak (*Quercus lobata*), Gooding's willow (*Salix gooddingii*), red willow, arroyo willow (*Salix lasiolepis*), California wild rose (*Rosa californica*), and narrowleaf willow. Generally, large container plants and live pole cuttings will be collected from areas adjacent to the project site or from riparian habitats within the Sacramento Valley at sites within a 50-mile radius of the project site.

Construction proceeds through a series of steps, beginning with the contractor placing rock revetment at the toe of the levee slope. The contractor next places a combination of rock and sandy soil to construct a bench. The proportion of rock to soil will be approximately 70:30. Once the bench is complete, soil will be placed over the bench area as a planting medium. The contractor may choose to use excavators, loaders, and other construction equipment on the construction area once the rock revetment is above the water surface.

Incorporation of environmental features that restore riparian and shaded riverine aquatic (SRA) habitat is a key aspect of the proposed action. As a result, off-site compensation and/or mitigation for impacts on these types of habitats from project construction activities will be implemented only to the extent that the project design does not fully offset these impacts.

B. Construction Schedule and Periods

Construction is scheduled to begin by in February. The placement of riprap, rock fill, and agricultural soil mix is anticipated to be completed during two construction periods, ranging from February 2007 through mid-May 2007. All instream construction work is anticipated to occur from during that period. Vegetation plantings are anticipated to occur during the spring of 2007.

C. Project Operation and Maintenance

Operation and Maintenance (O&M) activities that may be necessary for three to five years to maintain the flood control and environmental values at the site include removing invasive vegetation determined to be detrimental to the success of the project, pruning and irrigating planted vegetation to promote optimal growth, replacing vegetation plantings, monitoring navigational hazards, and placing fill and rock revetment if the site is damaged during high flow events or vandalism.

Maintenance of conservation measures will be conducted to the extent necessary to ensure that the overall long-term habitat effects of the project are positive, as determined by the SAM. The SAM quantifies habitat values in terms of bank line- or area-weighted species responses that are calculated by combining habitat quality (fish response indices) with quantity (bank length or wetted area) for each season, target year, and relevant species and life stage. The SAM employs six habitat variables to characterize nearshore and floodplain habitats of listed fish species.

This approach will adaptively manage project conservation measures based on SAM modeling, monitoring, and professional judgment. Once established, the riparian vegetation is expected to be self-maintaining.

In coordination with Federal and State resource agencies, any in-water work would be conducted during appropriate time periods to avoid adverse impacts to fish. The current proposed in-water work window is July 1 to October 30.

If O&M activities identify new technologies to enhance habitat values for Federally listed fish species, they will be considered for wider application to other eroding sites in the BALMD action area. Should the conservation measures fail, or be demonstrated as harmful to any Federally listed species, the Corps may request NMFS to consider allowing the O&M practices to lapse or for conservation measures to be implemented using modified techniques or at other locations.

D. Proposed Minimization and Conservation Measures

The Corps will incorporate the following permit conditions for the project, to help conserve and minimize impacts to listed species:

- Stockpiling of construction materials, including portable equipment, vehicles and supplies, including chemicals, shall be restricted to the designated construction staging areas and barges, exclusive of any riparian and wetlands areas.

- Erosion control measures (*i.e.*, Best Management Practices [BMPs]) that prevent soil or sediment from entering the river shall be placed, monitored for effectiveness, and maintained throughout the construction operations.

- All litter, debris, unused materials, equipment, and supplies shall be removed daily from any areas below the ordinary high water line and deposited at an appropriate disposal or storage site.

- Any spills of hazardous materials shall be cleaned up immediately and reported to the resource agencies within 24 hours. Any such spills, and the success of the efforts to clean them, shall also be reported in post-construction compliance reports.

- A representative shall be appointed who shall be the point-of-contact for any Corps employee, contractor, or contractor employee, who might incidentally take a living, or find a dead, injured, or entrapped threatened and endangered species during project construction and operations. This representative shall be identified to the employees and contractors during an all-employee education program relative to the various Federally listed species which may be encountered on the construction sites.

- If requested by the resource agencies, during or upon completion of construction activities, the environmental manger or contractor shall accompany USFWS or NMFS personnel on an on-site, post-construction inspection tour to review project impacts and restoration success.

- The intakes for any water pumps needed for the construction process shall be screened to NMFS salmonid-screening specifications.

- A biological representative shall work closely with the contractor(s) through all construction stages to ensure that any living riparian vegetation within "vegetation clearing zones," which can reasonably be avoided without compromising basic engineering design and safety, is avoided and left undisturbed to the extent feasible.

- Maintenance of conservation measures will be conducted to the extent necessary to ensure that the overall long-term habitat effects of the project are positive, as determined by the SAM. This approach will adaptively manage project conservation measures based on SAM modeling, monitoring, and professional judgment

- A study of the efficacy of integrated conservation measures (*i.e.*, plantings in riprap, planting bench, *etc*.) shall be instituted for a minimum of 5 years following construction. Focus of the study shall include, but not be limited to, sediment and organic matter retention and storage, habitat creation, and actual usage of the features by Federally listed and other fishes. Annual reports, and a final report deriving conclusions as to biological efficacy of the features, shall be provided to NMFS and the USFWS within 90 days of the study conclusion.

Furthermore, the proposed action will seek to avoid and minimize adverse effects to the extent feasible. There are a number of measures that will be applied to the entire project or specific aspects of the project and other measures that may be appropriate to implement at specific locations within the project footprint. Avoidance measures to be implemented during final design and construction may include, but are not limited to the following:

- Incorporate sensitive habitat information into project bid specifications.

- Fence sensitive habitats with orange construction fencing or similar material.

- Incorporate requirements for contractors to avoid identified sensitive habitats into project bid specifications.

- Minimize vegetation removal to the extent feasible, and leave as much existing IWM in place as possible.

- Perform no grubbing or contouring of the sites.

- Ensure all fill materials are placed with no excavation or movement of existing materials onsite.

- Ensure all construction activities; including clearing, pruning, and trimming of vegetation, is supervised by a qualified biologist to ensure these activities have a minimal effect on natural resources.

- If a cofferdam is needed during construction, it will be constructed by placing the sheet piles sequentially from the upstream to the downstream limits of the construction area. However, it is not anticipated at this time that a cofferdam will be needed. Prior to the closure of the cofferdam, seining will be conducted within the cofferdam with a small-mesh seine to direct fish out of the cofferdam and remove as many fish as possible. Upon completion of seining, exclusionary nets will be placed in the river to prevent fish from entering the cofferdam before the cofferdam is closed. When the cofferdam is partially dewatered, a final seining effort will be conducted within the cofferdam. Only low-flow pumps with screened intakes will be used during dewatering operations. If seining cannot rescue all listed species, a qualified fisheries biologist will use electrofishing to capture any remaining fish. All captured juvenile salmonids shall be released in the Sacramento River downstream of the construction area.

- Avoid direct and indirect effects on habitats containing or with a substantial possibility of containing listed terrestrial, wetland, and plant species to the extent feasible.

E. Proposed Compensation Measures

The BALMD and the Corps anticipate that the projects will largely be self-compensating due to the extensive environmental features proposed to maintain, protect, or create habitat features beneficial to anadromous salmonids. A final SAM analysis will be conducted after completion of construction. If this final SAM analysis or other evaluations indicate uncompensated habitat impacts, the Corps will pursue further conservation measures, including off-site compensation.

F. Monitoring

The Corps will, within 90 days of the completion of construction, submit a detailed, site-specific monitoring plan for the resource agencies (NMFS, USFWS, and the California Department of Fish and Game (CDFG)) to review. The Corps proposes to apply this plan to the critical erosion repair sites, and other sites, as necessary for approximately 5 years following construction. The monitoring plan will be incorporated into the O&M manual and implemented at all project sites. Elements of the monitoring plan include photographic documentation, riparian vegetation, SRA, shallow water habitat, instream vegetative cover, bank substrate size, and fish use of project sites using boat-mounted electrofishing, tagging or other procedures.

Monitoring is necessary to ensure that the vegetated benches and other conservation measures are functioning as projected by the SAM model. The Corps shall submit a yearly report of monitoring results to the resource agencies by December 31 of each year. Monitoring is to be conducted until such time as the projected benefits of mitigation actions to Federally listed fish species can either be substantially confirmed or discounted. If integrated conservation measures fail to meet modeled SAM values, specific remedial measures for each type of conservation measure (*i.e.*, riparian survival and growth) and the level of effort applied to implement such measures will be determined based on the magnitude and the causes of failure. Potential remedial measures may include: (1) planting additional vegetation at the project site, (2) extending the irrigation period, and (3) planting additional plants at offsite locations.

F. Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR § 402.02). The action area, for the purposes of this biological opinion includes the left bank of the Sacramento River from RM 16 downstream to RM 10, extending 100 feet off-shore into the river. This area was selected because it represents the upstream, downstream, and riverward extent of anticipated project actions.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed species evolutionary significant units (ESU) or distinct population segments (DPS) and designated critical habitat occur in the action area and may be affected by the proposed project:

Sacramento River winter-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
endangered (June 28, 2005, 70 FR 37160)

Sacramento River winter-run Chinook salmon designated critical habitat
(June 16, 1993, 58 FR 33212)
Central Valley spring-run Chinook salmon ESU (*Oncorhynchus tshawytscha*)
threatened (June 28, 2005, 70 FR 37160)
Central Valley spring-run Chinook salmon designated critical habitat
(September 2, 2005, 70 FR 52488)
Central Valley steelhead DPS (*Oncorhynchus mykiss*)
threatened (December 22, 2005)
Central Valley steelhead designated critical habitat
(September 2, 2005, 70 FR 52488)
Southern DPS of North American green sturgeon (*Acipenser medirostris*)
threatened (April 7, 2006, 70 FR 17386)

A. Species Life History, Population Dynamics, and Likelihood of Survival and Recovery

1. Chinook Salmon

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Spring-run Chinook salmon exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in fall, and the juveniles typically spend a year or more in freshwater before emigrating. Winter-run Chinook salmon are somewhat anomalous in that they have characteristics of both stream- and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run Chinook salmon migrate to sea after only 4 to 7 months of river life (ocean-type). Adequate instream flows and cool water temperatures are more critical for the survival of Chinook salmon exhibiting a stream-type life history due to over-summering by adults and/or juveniles.

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and the actual time of spawning (Myers *et al.* 1998). Both spring-run and winter-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

Information on the migration rates of Chinook salmon in freshwater is scant and primarily comes from the Columbia River basin where information regarding migration behavior is needed to assess the effects of dams on travel times and passage (Matter *et al*. 2003). Keefer *et al.* (2004) found migration rates of Chinook salmon ranging from approximately 10 kilometers (km) per day to greater than 35 km per day and to be primarily correlated with date, and secondarily with discharge, year, and reach, in the Columbia River basin. Matter *et al*. (2003) documented migration rates of adult Chinook salmon ranging from 29 to 32 km per day in the Snake River. Adult Chinook salmon inserted with sonic tags and tracked throughout the Delta and lower Sacramento and San Joaquin Rivers were observed exhibiting substantial upstream and downstream movement in a random fashion while migrating upstream (California Bay-Delta Authority (CALFED) Science Program 2001) several days at a time. Adult salmonids migrating upstream are assumed to make greater use of pool and mid-channel habitat than channel margins (Stillwater Sciences 2004), particularly larger salmon such as Chinook, as described by Hughes (2004). Adults are thought to exhibit crepuscular behavior during their upstream migrations; meaning that they primarily are active during twilight hours. Recent hydroacoustic monitoring conducted by LGL Environmental Research Associates (2006) showed peak upstream movement of adult Central Valley spring-run Chinook salmon (CV spring-run Chinook salmon) in lower Mill Creek, a tributary to the Sacramento River, occurring in the four hour period before sunrise and again after sunset.

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 1995). Upon emergence, fry swim or are displaced downstream (Healey 1991). Similar to adult movement, juvenile salmonid downstream movement is crepuscular. Documents and data provided to NMFS in support of ESA section 10 research permit applications depict that the daily migration of juveniles passing the Red Bluff Diversion Dam (RBDD) is highest in the four hour period prior to sunrise (Martin *et al.* 2001). Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in the stream for a period of time from weeks to a year (Healey 1991).

Fry then seek nearshore habitats containing beneficial aspects such as riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator avoidance, and slower velocities for resting (NMFS 1996). The benefits of shallow water habitats for salmonid rearing also have recently been realized as shallow water habitat has been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Meyer 1979, Healey 1980). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, MacFarlane and Norton 2001, Sommer *et al.* 2001).

As juvenile Chinook salmon grow they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures (Healey 1991).

Catches of juvenile salmon in the Sacramento River near West Sacramento by the USFWS (1997) exhibited larger juvenile captures in the main channel and smaller sized fry along the margins. When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1980). Stream flow and/or turbidity increases in the upper Sacramento River basin are thought to stimulate emigration (Kjelson *et al*. 1982, Brandes and McLain, 2001).

Juvenile Chinook salmon migration rates vary considerably presumably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al*. (1982) found fry Chinook salmon to travel as fast as 30 km per day in the Sacramento River and Sommer *et al.* (2001) found rates ranging from approximately 0.5 miles up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smoltification stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980, Levy and Northcote 1981).

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1981, Healey 1991). Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Juvenile Chinook salmon were found to spend about 40 days migrating through the Sacramento-San Joaquin Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallon Islands (MacFarlane and Norton 2001). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon) MacFarlane and Norton (2001) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry.

a. *Sacramento River Winter-run Chinook Salmon*

Sacramento River winter-run Chinook salmon originally were listed as threatened in August 1989, under emergency provisions of the Endangered Species Act (ESA), and formally listed as threatened in November 1990 (55 FR 46515). The ESU consists of only one population that is confined to the upper Sacramento River in California's Central Valley. The ESU was reclassified as endangered on January 4, 1994 (59 FR 440), due to increased variability of run sizes, expected weak returns as a result of two small year classes in 1991 and 1993, and a 99 percent decline between 1966 and 1991. NMFS reaffirmed the listing of Sacramento River winter-run Chinook salmon as endangered on June 28, 2005 (70 FR 37160). The Livingston Stone National Fish Hatchery population has been included in the listed Sacramento River winter-run Chinook salmon population as of June 28, 2005 (70 FR 37160). NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212).

Sacramento River winter-run Chinook salmon adults enter the Sacramento River basin between December and July; the peak occurring in March (Table 2; Yoshiyama *et al*. 1998, Moyle 2002). Spawning occurs primarily from mid-April to mid-August, with the peak activity occurring in May and June in the Sacramento River reach between Keswick Dam and RBDD (Vogel and Marine 1991). The majority of Sacramento River winter-run Chinook salmon spawners are 3 years old.

Sacramento River winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), with emergence generally occurring at night. Post-emergent fry disperse to the margins of the river, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on small insects and crustaceans.

Emigration of juvenile Sacramento River winter-run Chinook salmon past RBDD may begin as early as mid July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997). From 1995 to 1999, all Sacramento River winter-run Chinook salmon outmigrating as fry passed RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Martin *et al.* 2001). Juvenile Sacramento River winter-run Chinook salmon occur in the Delta primarily from November through early May based on data collected from trawls in the Sacramento River at West Sacramento (RM 57) (USFWS 2001). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Winter-run Chinook salmon juveniles remain in the Delta until they reach a fork length of approximately 118 millimeters (mm) and are from 5 to 10 months of age, and then begin emigrating to the ocean as early as November and continuing through May (Fisher 1994, Myers *et al.* 1998).

Since the listing of winter-run Chinook salmon, several habitat problems that led to the decline of the species have been addressed and improved through restoration and conservation actions. The impetus for initiating restoration actions stems primarily from the following: (1) ESA section 7 consultation Reasonable and Prudent Alternatives on temperature, flow, and operations of the Central Valley Project (CVP) and State Water Project (SWP); (2) Regional Water Quality Control Board (Regional Board) decisions requiring compliance with Sacramento River water temperature objectives which resulted in the installation of the Shasta Temperature Control Device in 1998; (3) a 1992 amendment to the authority of the CVP through the Central Valley Improvement Act (CVPIA) to give fish and wildlife equal priority with other CVP objectives; (4) fiscal support of habitat improvement projects from CALFED (*e.g.*, installation of a fish screen on the Glenn Colusa Irrigation District (GCID) diversion); (5) establishment of the CALFED Environmental Water Account (EWA); (6) Environmental Protection Agency actions to control acid mine runoff from Iron Mountain Mine; and, (7) ocean harvest restrictions implemented in 1995.

Historical Sacramento River winter-run Chinook salmon population estimates, which included males and females, were as high as near 100,000 fish in the 1960s; however, populations monotonically declined to under 200 fish in the 1990s (Good *et al.* 2005). Population estimates in 2003 (8,218), 2004 (7,701), and 2005 (15,730) show a recent increase in the population size CDFG GrandTab, February 2005, letter titled "Winter-run Chinook Salmon Escapement Estimates for 2005" from CDFG to NMFS, January 13, 2006) and a 3-year average of 10,550. The 2005 run was the highest since the listing. Overall, abundance measures suggest that the abundance is increasing (Good *et al*. 2005). Two current methods are utilized to estimate the juvenile production of Sacramento River winter-run Chinook salmon: the Juvenile Production Estimate (JPE) method and the Juvenile Production Index (JPI) method (Gaines and Poytress 2004). Gaines and Poytress (2004) estimated the juvenile population of Sacramento River winter-run Chinook salmon exiting the upper Sacramento River at RBDD to be 3,707,916 juveniles per year using the JPI method between the years 1995 and 2003 (excluding 2000 and 2001). Using the JPE method, they estimated an average of 3,857,036 juveniles exiting the upper Sacramento River at RBDD between the years of 1996 and 2003 (Gaines and Poytress 2004). Averaging these 2 estimates yields an estimated population size of 3,782,476.

Based on the RBDD counts, the population has been growing since the 1990s with positive short-term trends. An age-structured density-independent model of spawning escapement by Botsford and Brittnacker in 1998 (as referenced in Good *et al*. 2005) assessing the viability of Sacramento River winter-run Chinook salmon found the species was certain to fall below the quasi-extinction threshold of 3 consecutive spawning runs with fewer than 50 females (Good *et al*. 2005). Lindley *et al*. (2003) assessed the viability of the population using a Bayesian model based on spawning escapement that allowed for density dependence and a change in population growth rate in response to conservation measures found a biologically significant expected quasi-extinction probability of 28 percent. Although the status of the Sacramento River winter-run Chinook salmon population is improving, there is only one population, and it depends on cold-water releases from Shasta Dam, which could be vulnerable to a prolonged drought (Good *et al*. 2005). Although NMFS recently proposed that this ESU be upgraded from endangered to threatened status, it made the decision in its Final Listing Determination (June 28, 2005, 70 FR 37160) to continue to list the Sacramento River winter-run Chinook salmon ESU as endangered. This population remains below the draft recovery goals established for the run (NMFS 1997, 1998) and the naturally-spawned component of the ESU is dependent on one extant population in the Sacramento River. In general, the recovery criteria for Sacramento River winter-run Chinook salmon include a mean annual spawning abundance over any 13 consecutive years of at least 10,000 females with a concurrent geometric mean of the cohort replacement rate greater than 1.0 (NMFS 1997). Recent trends in Sacramento River winter-run Chinook salmon abundance and cohort replacement remain positive, indicating some recovery since the listing. However, the population remains well below the recovery goals of the draft recovery plan, and is particularly susceptible to extinction because of the reduction of the genetic pool to one population.

Table 2. The temporal occurrence of adult (a) and juvenile (b) Sacramento River winter-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River basin[1]												
Sac. River[2]												

b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sac. River @ Red Bluff[3]												
Sac. River @ Red Bluff[2]												
Sac. River @ Knights L.[4]												
Lower Sac. River (seine)[5]												
West Sac. River (trawl)[5]												

Source: [1]Yoshiyama *et al*. 1998; Moyle 2002; [2]Myers *et al*. 1998; [3]Martin *et al.* 2001; [4]Snider and Titus 2000; [5]USFWS 2001

Relative Abundance: = High = Medium = Low

b. *Central Valley Spring-run Chinook Salmon*

NMFS listed the CV spring-run Chinook salmon ESU as threatened on September 16, 1999 (64 FR 50394). In June 2004, NMFS proposed that CV spring-run Chinook salmon remain listed as threatened (69 FR 33102). This proposal was based on the recognition that although CV spring-run Chinook salmon productivity trends are positive, the ESU continues to face risks from having a limited number of remaining populations (*i.e.*, 3 existing populations from an estimated 17 historical populations), a limited geographic distribution, and potential hybridization with Feather River Hatchery (FRH) spring-run Chinook salmon, which until recently were not included in the ESU and are genetically divergent from other populations in Mill, Deer, and Butte Creeks. On June 28, 2005, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of CV spring-run Chinook salmon as threatened (70 FR 37160). This decision also included the FRH spring-run Chinook salmon population as part of the CV spring-run Chinook salmon ESU. Critical habitat was designated for CV spring-run Chinook salmon on September 2, 2005 (70 FR 52488).

Adult CV spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFG 1998) and enter the Sacramento River between March and September, primarily in May and June (Table 3, Yoshiyama *et al*. 1998, Moyle 2002). Lindley *et al*. (2006a) indicates adult CV spring-run Chinook salmon enter native tributaries from the Sacramento River primarily between mid April and mid June. Typically, spring-run Chinook salmon utilize mid- to high-elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature (Yoshiyama *et al*. 1998).

Spring-run Chinook salmon fry emerge from the gravel from November to March (Moyle 2002) and the emigration timing is highly variable, as they may migrate downstream as young-of-the-year or as juveniles or yearlings. The modal size of fry migrants at approximately 40 mm between December and April in Mill, Butte, and Deer Creeks reflects a prolonged emergence of fry from the gravel (Lindley *et al*. 2006a). Studies in Butte Creek (Ward *et al*. 2002, 2003, and McReynolds *et al*. 2005,) found the majority of CV spring-run Chinook salmon migrants to be fry occurring primarily during December, January and February; and that these movements appeared to be influenced by flow. Small numbers of CV spring-run Chinook salmon remained in Butte Creek to rear and migrated as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer Creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer Creek juveniles typically exhibit a later young-of-the year migration and an earlier yearling migration (Lindley *et al*. 2006a).

Once juveniles emerge from the gravel they initially seek areas of shallow water and low velocities while they finish absorbing the yolk sac (Moyle 2002). Many also will disperse downstream during high-flow events. As is the case in other salmonids, there is a shift in microhabitat use by juveniles to deeper faster water as they grow. Microhabitat use can be influenced by the presence of predators which can force fish to select areas of heavy cover and suppress foraging in open areas (Moyle 2002). Peak movement of juvenile CV spring-run Chinook salmon in the Sacramento River at Knights Landing occurs in December, and again in March and April; however, juveniles also are observed between November and the end of May (Snider and Titus 2000).

CV spring-run Chinook salmon were once the most abundant run of salmon in the Central Valley (Campbell and Moyle 1992) and were found in both the Sacramento and San Joaquin drainages. More than 500,000 CV spring-run Chinook salmon were caught in the Sacramento-San Joaquin commercial fishery in 1883 alone (Yoshiyama *et al.* 1998). The San Joaquin populations essentially were extirpated by the 1940s, with only small remnants of the run that persisted through the 1950s in the Merced River (Yoshiyama *et al.* 1998). Populations in the upper Sacramento, Feather, and Yuba Rivers were eliminated with the construction of major dams during the 1950s and 1960s. Naturally spawning populations of CV spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Mill Creek, Feather River, and the Yuba River (CDFG 1998).

Table 3. The temporal occurrence of adult (a) and juvenile (b) CV spring-run Chinook salmon in the Sacramento River. Darker shades indicate months of greatest relative abundance.

(a) Adult

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2]Sac.River basin												
[3]Sac. River												
[4]Mill Creek												
[4]Deer Creek												
[4]Butte Creek												

(b) Juvenile

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[5]Sac. River Tribs												
[6]Upper Butte Creek												
[4]Mill, Deer, Butte Creeks												
[3]Sac. River at RBDD												
[7]Sac. River at KL												

Source:[1]Yoshiyama *et al*. 1998; [2]Moyle 2002; [3]Myers *et al*. 1998; [4]Lindley *et al*. 2006a; [5]CDFG 1998; [6]McReynolds *et al*. 2005; Ward *et al*. 2002, 2003; [7]Snider and Titus 2000

Relative Abundance: = High = Medium = Low

The CV spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance, ranging from 1,403 in 1993 to 25,890 in 1982. The average abundance for the ESU was 12,590 for the period of 1969 to 1979, 13,334 for the period of 1980 to 1990, 6,554 from 1991 to 2001, and 16,349 between 2002 and 2005 (for the purposes of this biological opinion, the average adult population is assumed to be 16,349 until new information is available. Sacramento River tributary populations in Mill, Deer, and Butte Creeks are probably the best trend indicators for the Central Valley spring-run Chinook salmon ESU as a whole because these streams contain the primary independent populations with the ESU. Generally, these streams have shown a positive escapement trend since 1991. Escapement numbers are dominated by Butte Creek returns, which have averaged over 7,000 fish since 1995. During this same period, adult returns on Mill Creek have averaged 778 fish, and 1,463 fish on Deer Creek. Although recent trends are positive, annual abundance estimates display a high level of fluctuation, and the overall number of CV spring-run Chinook salmon remains well below estimates of historic abundance.

Additionally, in 2003, high water temperatures, high fish densities, and an outbreak of Columnaris Disease (*Flexibacter columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) contributed to the pre-spawning mortality of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek.

Several actions have been taken to improve habitat conditions for CV spring-run Chinook salmon, including: improved management of Central Valley water (*e.g.*, through use of CALFED EWA and CVPIA (b) (2) water accounts); implementing new and improved screen and ladder designs at major water diversions along the mainstem Sacramento River and tributaries; and, changes in ocean and inland fishing regulations to minimize harvest. Although protective measures likely have contributed to recent increases in spring-run Chinook salmon abundance, the ESU is still below levels observed from the 1960s through 1990. Threats from hatchery production (*i.e.*, competition for food between naturally spawned and hatchery fish, run hybridization and genomic homogenization), climatic variation, high temperatures, predation, and water diversions still persist.

2. <u>Central Valley Steelhead</u>

Central Valley steelhead (CV steelhead) were originally listed as threatened on March 19, 1998 (63 FR 13347). This DPS consists of steelhead populations in the Sacramento and San Joaquin River basins in California's Central Valley. In June 2004, NMFS proposed that CV steelhead remain listed as threatened (69 FR 33102). On June 28, 2005, after reviewing the best available scientific and commercial information, NMFS issued its final decision to retain the status of CV steelhead as threatened (70 FR 37160). This decision also included the Coleman National Fish Hatchery and FRH steelhead populations. These populations were previously included in the DPS but were not deemed essential for conservation and thus not part of the listed steelhead population. Critical habitat was designated for CV steelhead on September 2, 2005 (70 FR 52488).

Steelhead can be divided into two life history types, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Stream-maturing steelhead enter freshwater in a sexually immature condition and require several months to mature and spawn, whereas ocean-maturing steelhead enter freshwater with well-developed gonads and spawn shortly after river entry. These two life history types are more commonly referred to by their season of freshwater entry (*i.e.*, summer (stream-maturing) and winter (ocean-maturing) steelhead). Only winter steelhead currently are found in Central Valley rivers and streams (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento river system prior to the commencement of large-scale dam construction in the 1940s (Interagency Ecological Program (IEP) Steelhead Project Work Team 1999). At present, summer steelhead are found only in North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity River systems (McEwan and Jackson 1996).

CV steelhead generally leave the ocean from August through April (Busby *et al.* 1996), and spawn from December through April with peaks from January though March in small streams and tributaries where cool, well-oxygenated water is available year-round (Hallock *et al.* 1961, McEwan and Jackson 1996,) (Table 4). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapolov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams.

The female selects a site where there is good intergravel flow, then digs a redd and deposits eggs while an attendant male fertilizes them. The eggs are then covered with gravel when the female begins excavation of another redd just upstream. The length of time it takes for eggs to hatch depends mostly on water temperature. Hatching of steelhead eggs in hatcheries takes about 30 days at 51 °F. Fry emerge from the gravel usually about four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft 1954). Newly emerged fry move to the shallow, protected areas associated with the stream margin (McEwan and Jackson 1996) and they soon move to other areas of the stream and establish feeding locations, which they defend (Shapovalov and Taft 1954).

Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-the-year also are abundant in glides and riffles. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Meehan and Bjornn 1991).

Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating CV steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Juvenile CV steelhead feed mostly on drifting aquatic organisms and terrestrial insects and will also take active bottom invertebrates (Moyle 2002).

Some may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento River basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall. Nobriga and Cadrett (2001) also have verified these temporal findings based on analysis of captures at Chipps Island, Suisun Bay.

CV steelhead historically were well-distributed throughout the Sacramento and San Joaquin Rivers (Busby *et al.* 1996) and were found from the upper Sacramento and Pit River systems (now inaccessable due to Shasta and Keswick Dams) south to the Kings and possibly the Kern

River systems, and in both east- and west-side Sacramento River tributaries (Yoshiyama *et al.* 1996). Lindley *et al*. (2006b) estimated that historically there were at least 81 independant CV steelhead populations distributed primarily throughout the eastern tributaries of the Sacramento and San Joaquin Rivers. This distribution has been greatly affected by dams (McEwan and Jackson 1996). Presently, impassable dams block access to 80 percent of historically available habitat, and block access to all historical spawning habitat for about 38 percent of historical populations (Lindley *et al*. 2006b).

Historic CV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached 1 to 2 million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally-spawned steelhead populations in the upper Sacramento River have declined substantially. Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River, upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

Recent estimates from trawling data in the Delta indicate that approximately 100,000 to 300,000 (mean 200,000) smolts emigrate to the ocean per year representing approximately 3,600 female CV steelhead spawners in the Central Valley basin (Good *et al*. 2005). This can be compared with McEwan's (2001) estimate of 1 million to 2 million spawners before 1850, and 40,000 spawners in the 1960s.

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River.

It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, throughout accessible streams and rivers in the Central Valley (Good *et al*. 2005). CDFG staff has prepared juvenile migrant CV steelhead catch summaries on the San Joaquin River near Mossdale representing migrants from the Stanislaus, Tuolumne, and Merced Rivers. Based on trawl recoveries at Mossdale between 1988 and 2002, as well as rotary screw trap efforts in all three tributaries, CDFG staff stated that it is “clear from this data that rainbow trout do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanislaus River” (Letter from Dean Marston, CDFG, to Madelyn Martinez, NMFS, January 9, 2003). The documented returns on the order of single fish in these tributaries suggest that existing populations of CV steelhead on the Tuolumne, Merced, and lower San Joaquin Rivers are severely depressed.

Table 4. The temporal occurrence of adult (a) and juvenile (b) CV steelhead in the Central Valley. Darker shades indicate months of greatest relative abundance.

(a) Adult

Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[1,3]Sac. River	L	L	L	L	L	L						L	L	L	L	M	M	H	H	M	L	L	L	L
[2,3]Sac R at Red Bluff	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	M	H	M	L	L	L	L
[4]Mill, Deer Creeks			H	M	M	L	L	L	L	L	L	L								H	H	M	M	M
[6]Sac R. at Fremont Weir	L	L	L	L											M	M	H	H	M	M	L	L	L	L
[6]Sac R. at Fremont Weir	L	L	L	L											M	M	H	H	M	M	L	L	L	L
[7]San Joaquin River	M	M	M	M	M	M							L	L	L	L	M	M	M	M	M	M	H	H

(b) Juvenile

Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
[1,2]Sacramento River	L	L	L	L	M	M	M	M	M	M	M	M	L	L	L	L	L	L	M	M	M	M	L	L
[2,8]Sac. R at Knights Land	L	L	L	L	H	H	L	L	L															L
[9]Sac. River @ KL	M	M	M	M	H	H	H	H	M	M											L	L	L	L
[10]Chipps Island (wild)	L	L	L	L	H	H	H	H	M	M	M	M	L	L					L	L	L	L	L	L
[8]Mossdale							H	H	H	H														
[11]Woodbridge Dam	M	M	M	M	M	M	M	M	M	M	M	M	M	M										
[12]Stan R. at Caswell	L	L	M	M	H	H	M	M	M	M	L	L												
[13]Sac R. at Hood	L	L	H	H	H	H	H	H	H	H											L	L	L	L

Source: [1]Hallock 1961; [2]McEwan 2001; [3]USFWS unpublished data; [4]CDFG 1995; [5]Hallock *et al*. 1957; [6]Bailey 1954; [7]CDFG Steelhead Report Card Data; [8]CDFG unpublished data; [9]Snider and Titus 2000; [10]Nobriga and Cadrett 2001; [11]Jones & Stokes Associates, Inc., 2002; [12]S.P. Cramer and Associates, Inc. 2000 and 2001; [13]Schaffter 1980

Relative Abundance: H = High; M = Medium; L = Low

Lindley *et al.* (2006b) indicated that prior population census estimates completed in the 1990s found the CV steelhead spawning population above RBDD had a fairly strong negative population growth rate and small population size. Good *et al.* (2005) indicated the decline was continuing as evidenced by new information (Chipps Island trawl data). The future of CV steelhead is uncertain due to limited data concerning their status. CV steelhead populations generally show a continuing decline, an overall low abundance, and fluctuating return rates.

3. Southern DPS of North American Green Sturgeon

The Southern DPS of North American green sturgeon was listed as threatened on April 7, 2006, (70 FR 17386) and includes the North American green sturgeon population spawning in the Sacramento River and utilizing the Sacramento River, the Delta, and the San Francisco Estuary.

North American green sturgeon are widely distributed along the Pacific Coast and have been documented offshore from Ensenada Mexico to the Bering Sea and found in rivers from British Columbia to the Sacramento River (Moyle 2002). As is the case for most sturgeon, North American green sturgeon are anadromous; however, they are the most marine-oriented of the sturgeon species (Moyle 2002). In North America, spawning populations of the anadromous green sturgeon currently are found in only three river systems, the Sacramento and Klamath Rivers in California and the Rogue River in southern Oregon.

Two green sturgeon DPSs were identified based on evidence of spawning site fidelity (indicating multiple DPS tendencies), and on the preliminary genetic evidence that indicates differences at least between the Klamath River and San Pablo Bay samples (Adams *et al*. 2002). The Northern DPS includes all green sturgeon populations starting with the Eel River and extending northward. The Southern DPS would include all green sturgeon populations south of the Eel River with the only known spawning population being in the Sacramento River.

The Southern DPS of North American green sturgeon life cycle can be broken into four distinct phases based on developmental stage and habitat use: (1) adult females greater than or equal to 13 years of age and males greater than or equal to 9 years of age, (2) larvae and post-larvae less than 10 months of age, (3) juveniles less than or equal to 3 years of age, and (4) coastal migrant females between 3 and 13, and males between 3 and 9 years of age (Nakamoto *et al*. 1995; Jeff McLain, NMFS, pers. comm., 2006).

New information regarding the migration and habitat use of the Southern DPS of North American green sturgeon has emerged. Lindley (2006c) presents preliminary results of large-scale green sturgeon migration studies. Lindley's analysis verified past population structure delineations based on genetic work and found frequent large-scale migrations of green sturgeon along the Pacific Coast. It appears North American green sturgeon are migrating considerable distances up the Pacific Coast into other estuaries, particularly the Columbia. This information also agrees with the results of green sturgeon tagging studies completed by CDFG where they tagged a total of 233 green sturgeon in the San Pablo Estuary between 1954 and 2001. A total of 17 tagged fish were recovered: 3 in the Sacramento-San Joaquin Estuary, 2 in the Pacific Ocean off of California, and 12 from commercial fisheries off of Oregon and Washington. Eight of the 12 recoveries were in the Columbia Estuary (CDFG 2002). In addition, recent analysis by Israel (2006) indicates a substantial component of the population (*i.e.*, 50-80 percent) of Southern DPS North American green sturgeon to be present in the Columbia estuary.

Kelley *et al.* (2006) indicated that green sturgeon enter the San Francisco Estuary during the spring and remain until autumn. The authors studied the movement of adults in the San Francisco Estuary and found them to make significant long-distance movements with distinct directionality. The movements were not found to be related to salinity, current, or temperature and the authors surmised they are related to resource availability (Kelley *et al*. 2006). Green sturgeon were most often found at depths greater than 5 meters with low or no current during summer and autumn months (Erickson *et al*. 2002). The majority of green sturgeon in the Rogue River emigrated from freshwater habitat in December after water temperatures dropped (Erickson *et al*. 2002). The authors surmised that this holding in deep pools was to conserve energy and utilize abundant food resources. Based on captures of adult green sturgeon in holding pools on the Sacramento River above the GCID diversion (RM 205) and the documented presence of adults in the Sacramento River during the spring and summer months and the presence of larval green sturgeon in late summer in the lower Sacramento River indicating spawning occurrence, it appears adult green sturgeon could possibly utilize a variety of freshwater and brackish habitats for up to nine months of the year (Ray Beamesderfer, S.P. Cramer & Associates, Inc., pers. comm. 2006).

Green sturgeon larvae do not exhibit the initial pelagic swim-up behavior characteristic of other *Acipenseridae*. They are strongly oriented to the bottom and exhibit nocturnal activity patterns. Under laboratory conditions, green sturgeon larvae cling to the bottom during the day, and move into the water column at night (Van Eenennaam *et al*. 2001). After six days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile green sturgeon continue to exhibit nocturnal behavior beyond the metamorphosis from larvae to juvenile stages. Laboratory studies by Kynard *et al*. (2005) indicated that juvenile fish continued to migrate downstream at night for the first six months of life. These data suggest that 9-to 10-month-old fish would hold over in their natal rivers during the ensuing winter at a location downstream of their spawning grounds. Juvenile green sturgeon have been salvaged at the Harvey O. Banks Pumping Plant and the John E. Skinner Fish Facility (Fish Facilities) in the South Delta, and captured in trawling studies by the CDFG during all months of the year (CDFG 2002). The majority of these fish were between 200 and 500 mm indicating they were from 2 to 3 years of age based on Klamath River age distribution work by Nakamoto *et al*. (1995). The lack of a significant proportion of juveniles smaller than approximately 200 mm in Delta captures indicates juvenile Southern DPS North American green sturgeon likely hold in the mainstem Sacramento River as suggested by Kyndard *et al*. (2005).

Population abundance information concerning the Southern DPS green sturgeon is described in the NMFS status reviews (Adams *et al*. 2002, NMFS 2005a). Limited population abundance information comes from incidental captures of North American green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002). CDFG (2002) utilizes a multiple-census or Peterson mark-recapture method to estimate the legal population of white sturgeon captures in trammel nets. By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile North American green sturgeon per year (Adams *et al*. 2002). The only existing information regarding changes in the abundance of the Southern DPS of green sturgeon includes changes in abundance at the John E. Skinner Fish Facility between 1968 and 2001. The average number of North American green sturgeon taken per year at the State Facility prior to 1986 was 732; from 1986 on, the average per year was 47 (70 FR 17386). For the Harvey O. Banks Pumping Plant, the average number prior to 1986 was 889; from 1986 to 2001 the average was 32 (70 FR 17386). In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the Southern DPS of North American green sturgeon is dropping.

There are at least two records of confirmed adult sturgeon observation in the Feather River (Beamesderfer *et al*. 2004), however, there are no observations of juvenile or larval sturgeon even prior to the 1960s when Oroville Dam was built (NMFS 2005a). There are also unconfirmed reports that green sturgeon may spawn in the Feather River during high flow years (CDFG 2002).

Spawning in the San Joaquin River system has not been recorded, but alterations of the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced Rivers) and its mainstem occurred early in the European settlement of the region. During the later half of the 1800s impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for over a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. It is likely that both white and green sturgeon utilized the San Joaquin River basin for spawning prior to the onset of European influence, based on past use of the region by populations of CV spring-run Chinook salmon and CV steelhead. These two populations of salmonids have either been extirpated or greatly diminished in their use of the San Joaquin River basin over the past two centuries.

Recent habitat evaluations conducted in the upper Sacramento River for salmonid recovery planning (Lindley *et al*. 2006b) suggests that significant potential green sturgeon spawning habitat was made inaccessible or altered by dams (historical habitat characteristics, temperatures, and geology summarized). This spawning habitat may have extended into the three major branches of the Sacramento River; the Little Sacramento River, the Pit River system, and the McCloud River (NMFS 2005a). Due to substantial habitat loss as well as existing threats to the Southern DPS of North American green sturgeon, it continues to remain at a moderate to high risk of extinction.

The freshwater habitat of North American green sturgeon in the Sacramento-San Joaquin drainage varies in function, depending on location. Spawning areas currently are limited to accessible upstream reaches of the Sacramento River. Preferred spawning habitats are thought to contain large cobble in deep cool pools with turbulent water (CDFG 2002, Moyle 2002).

Table 5. The temporal occurrence of adult (a) larval and post-larval (b) juvenile (c) and coastal migrant (d) Southern DPS of North American green sturgeon. Locations emphasize the Central Valley of California. Darker shades indicate months of greatest relative abundance.

(a) Adult (≥13 years old for females and ≥9 years old for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[1,2,3]Upper Sac. River												
[4,8]SF Bay Estuary												

(b) Larval and post-larval (≤10 months old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[5]RBDD, Sac River												
[5]GCID, Sac River												

(c) Juvenile (> 10 months old and ≤3 years old)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[6]South Delta*												
[6]Sac-SJ Delta												
[5]Sac-SJ Delta												
[5]Suisun Bay												

(d) Coastal migrant (3-13 years old for females and 3-9 years old for males)

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
[3,7]Pacific Coast												

Source: [1]USFWS 2002; [2]Moyle *et al*. 1992; [3]Adams *et al*. 2002 and NMFS 2005a; [4]Kelley *et al*. 2006; [5]CDFG 2002; [6]Interagency Ecological Program Relational Database, fall midwater trawl green sturgeon captures from 1969 to 2003; [7]Nakamoto *et al*. 1995; [8]Heublein *et al*. 2006
* Fish Facility salvage operations

Relative Abundance: = High = Medium = Low

Migratory corridors are downstream of the spawning areas and include the mainstem Sacramento River and the Delta. These corridors allow the upstream passage of adults and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers which can include dams, unscreened or poorly screened diversions, and degraded water quality. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their 1 to 3 year residence in freshwater.

Rearing habitat condition and function may be affected by variation in annual and seasonal flow and temperature characteristics.

B. Critical Habitat and Primary Constituent Elements

The designated critical habitat for Sacramento River winter-run Chinook salmon includes the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Delta; all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Estuary to the Golden Gate Bridge north of the San Francisco/Oakland Bay Bridge. In the Sacramento River, critical habitat includes the river water column, river bottom, and adjacent riparian zone used by fry and juveniles for rearing. In the areas westward of Chipps Island, critical habitat includes the estuarine water column and essential foraging habitat and food resources used by Sacramento River winter-run Chinook salmon as part of their juvenile emigration or adult spawning migration.

Critical habitat for CV spring-run Chinook salmon includes stream reaches such as those of the Feather and Yuba Rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear Creeks, and the Sacramento River and Delta. Critical Habitat for CV steelhead includes stream reaches such as those of the Sacramento, Feather, and Yuba Rivers, and Deer, Mill, Battle, and Antelope creeks in the Sacramento River basin; and, the San Joaquin River its tributaries, and the Delta. Critical habitat includes the stream channels in the designated stream reaches and the lateral extent as defined by the ordinary high-water line. In areas where the ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation (defined as the level at which water begins to leave the channel and move into the floodplain; it is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series) (70 FR 52488). Critical habitat for CV spring-run Chinook salmon and steelhead is defined as specific areas that contain the primary constituent elements (PCE) and physical habitat elements essential to the conservation of the species. Following are the inland habitat types used as PCEs for CV spring-run Chinook salmon and CV steelhead and as physical habitat elements for Sacramento River winter-run Chinook salmon.

1. <u>Spawning Habitat</u>

Freshwater spawning sites are those with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development. Most spawning habitat in the Central Valley for Chinook salmon and steelhead is located in areas directly downstream of dams containing suitable environmental conditions for spawning and incubation. Spawning habitat for Sacramento River winter-run Chinook salmon is restricted to the Sacramento River primarily between RBDD and Keswick Dam. CV spring-run Chinook salmon also spawn on the mainstem Sacramento River between RBDD and Keswick Dam and in tributaries such as Mill, Deer, and Butte Creeks. Spawning habitat for CV steelhead is similar in nature to the requirements of Chinook salmon, primarily occurring in reaches directly below dams (*i.e.*, above RBDD on the

Sacramento River) throughout the Central Valley. Spawning habitat has a high conservation value as its function directly affects the spawning success and reproductive potential of listed salmonids.

2. Freshwater Rearing Habitat

Freshwater rearing sites are those with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing. Rearing habitat condition is strongly affected by habitat complexity, food supply, and presence of predators of juvenile salmonids. Some complex, productive habitats with floodplains remain in the system (*e.g.*, the lower Cosumnes River, Sacramento River reaches with set-back levees [*i.e.*, primarily located upstream of the City of Colusa]). However, the channeled, leveed, and riprapped river reaches and sloughs that are common in the Sacramento-San Joaquin system typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. Freshwater rearing habitat also has a high conservation value as the juvenile life stage of salmonids is dependant on the function of this habitat for successful survival and recruitment.

3. Freshwater Migration Corridors

Ideal freshwater migration corridors are free of obstruction with water quantity and quality conditions and contain natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility, survival and food supply. Migratory corridors are downstream of the spawning area and include the lower Sacramento River and the Delta. These corridors allow the upstream passage of adults, and the downstream emigration of outmigrant juveniles. Migratory habitat condition is strongly affected by the presence of barriers, which can include dams, unscreened or poorly- screened diversions, and degraded water quality. For successful survival and recruitment of salmonids, freshwater migration corridors must function sufficiently to provide adequate passage. For this reason, freshwater migration corridors are considered to have a high conservation value.

4. Estuarine Areas

Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and salt water are included as a PCE. Natural cover such as submerged and overhanging large wood, aquatic vegetation, and side channels, are suitable for juvenile and adult foraging. Estuarine areas contain a high conservation value as they function as predator avoidance and as a transition to the ocean environment.

C. Factors Affecting the Species and Critical Habitat

1. Chinook Salmon and Central Valley Steelhead

A number of documents have addressed the history of human activities, present environmental conditions, and factors contributing to the decline of salmon and steelhead species in the Central Valley. For example, NMFS prepared range-wide status reviews for west coast Chinook salmon (Myers *et al*. 1998) and steelhead (Busby *et al*. 1996). Also, the NMFS Biological Review Team (BRT) published a draft updated status review for west coast Chinook salmon and steelhead in November 2003 (NMFS 2003), and an additional updated and final draft in 2005 (Good *et al*. 2005). NMFS also assessed the factors for Chinook salmon and steelhead decline in supplemental documents (NMFS 1996, 1998). Information also is available in Federal Register notices announcing ESA listing proposals and determinations for some of these species and their critical habitat (*e.g.*, 58 FR 33212; 59 FR 440; 62 FR 24588; 62 FR 43937; 63 FR 13347; 64 FR 24049; 64 FR 50394; 65 FR 7764). The Final Programmatic Environmental Impact Statement/Report (EIS/EIR) for the CALFED Program (California Bay-Delta Program 2000) and the Final Programmatic EIS for the CVPIA provide a summary of historical and recent environmental conditions for salmon and steelhead in the Central Valley. The following general description of the status of species for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead is based on a summarization of these documents.

In general, the human activities that have affected listed anadromous salmonids and the PCEs of their critical habitats consist of: (1) the present or threatened destruction, modification, or curtailment of habitat or range; (2) over-utilization; (3) disease or predation; and, (4) other natural and manmade factors.

a. *Habitat Blockage*

Hydropower, flood control, and water supply dams of the CVP, SWP, and other municipal and private entities have permanently blocked or hindered salmonid access to historical spawning and rearing grounds resulting in the complete loss of substantial portions of spawning, rearing, and migration PCEs. Clark (1929) estimated that originally there were 6,000 linear miles of salmon habitat in the Central Valley system and that 80 percent of this habitat had been lost by 1928. Yoshiyama *et al.* (1996) calculated that roughly 2,000 linear miles of salmon habitat actually was available before dam construction and mining, and concluded that 82 percent is not accessible today. Yoshiyama *et al*. (1996) surmised that steelhead habitat loss was even greater than salmon loss, as steelhead migrated farther into drainages. The California Advisory Committee on Salmon and Steelhead Trout (1988) estimated that there has been a 95 percent reduction of Central Valley anadromous fish spawning habitat.

In general, large dams on every major tributary to the Sacramento River, San Joaquin River, and the Delta block salmon and steelhead access to the upper portions of their respective watersheds. On the Sacramento River, Keswick Dam blocks passage to historic spawning and rearing habitat in the upper Sacramento, McCloud, and Pit Rivers. Whiskeytown Dam blocks access to the upper watershed of Clear Creek. Oroville Dam and associated facilities block passage to the upper Feather River watershed. Nimbus Dam blocks access to most of the American River basin. Friant Dam construction in the mid 1940s has been associated with the elimination of spring-run Chinook salmon in the San Joaquin River upstream of the Merced River. On the Stanislaus River, construction of Goodwin Dam (1912), Tulloch Dam (1957), and New Melones Dam (1979) blocked both spring- and fall-run Chinook salmon as well as CV steelhead. Similarly, La Grange Dam (1893) and New Don Pedro Dam (1971) blocked upstream access to salmonids on the Tuolumne River. Upstream migration on the Merced River was blocked in 1910 by the construction of Merced Falls and Crocker-Huffman Dams and later New Exchequer Dam (1967) and McSwain Dam (1967).

Changes in the thermal profiles and hydrographs of the Central Valley rivers presumably have subjected salmonids to strong selective forces (Slater 1963). The degree to which current life history traits reflect predevelopment characteristics is largely unknown, especially since most of the habitat degradation occurred before salmonid studies were undertaken late in the nineteenth century. Increased temperatures as a result of reservoir operations during winter and fall can affect emergence rates of Chinook salmon; thereby significantly altering the life history of a species (CALFED 2005). Shifts in life history have the potential to seriously affect survival (CALFED 2005).

Central Valley Chinook salmon exhibit an ocean-type life history; large numbers of juvenile Chinook salmon emigrate during the winter and spring (Kjelson *et al*. 1982, Gard 1995). High summer water temperatures in the lower Sacramento River (temperatures in the Delta can exceed 72 °F) create a thermal barrier to up- and downstream migration and may be partially responsible for the evolution of the fry migration life history (Kjelson *et al*. 1982).

The distribution of Sacramento River winter-run Chinook salmon spawning and rearing historically was limited to the upper Sacramento River and its tributaries, where spring-fed streams allowed for spawning, egg incubation, and rearing in cold water (Slater 1963, Yoshiyama *et al.* 1998). The headwaters of the McCloud, Pit, and Little Sacramento Rivers, and Hat and Battle Creeks, historically provided clean, loose gravel; cold, well-oxygenated water; and, optimal stream flows in riffle habitats for spawning and incubation. These areas also provided the cold, productive waters necessary for egg and fry development and survival, and juvenile rearing over the summer. The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which has its own impediments to upstream migration (*i.e.*, the fish weir at the Coleman National Fish Hatchery and other small hydroelectric facilities situated upstream of the weir) (Moyle *et al.* 1989, NMFS 1997). Approximately, 299 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to winter-run Chinook salmon. Yoshiyama *et al.* (2001) estimated that in 1938, the Upper Sacramento had a "potential spawning capacity" of 14,303 redds. Most components of the winter-run Chinook salmon life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River.

The initial factors that led to the decline of CV spring-run Chinook salmon in the Central Valley also were related to the loss of upstream habitat behind impassable dams. Since spring-run Chinook salmon adults must hold over for months in small tributaries before spawning, they are much more susceptible to the effects of high water temperatures. The loss of upstream habitat had required CV spring-run Chinook salmon to less hospitable reaches below dams.

The loss of substantial habitat above dams also has resulted in decreased juvenile and adult steelhead survival during migration, and in many cases, had resulted in the dewatering and loss of important spawning and rearing habitats.

b. *Water Diversion*

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted stream flows and altered the natural cycles by which juvenile and adult salmonids have evolved. Changes in stream flows and diversions of water affect spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitat PCEs. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta has been diverted for human uses. Depleted flows have contributed to higher temperatures, lower dissolved oxygen (DO) levels, and decreased recruitment of gravel and IWM. More uniform flows year-round have resulted in diminished natural channel formation, altered food web processes, and slower regeneration of riparian vegetation. These stable flow patterns have reduced bedload movement, caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams. In addition, Brown and May (2000) found stream regulation to be associated with declines in benthic macroinvertebrate communities in Central Valley rivers. Macroinvertebrates are key prey species for salmonids.

Water withdrawals, for agricultural and municipal purposes have reduced river flows and increased temperatures during the critical summer months, and in some cases, have been of a sufficient magnitude to result in reverse flows in the lower San Joaquin River (Reynolds *et al*. 1993). Direct relationships exist between water temperature, water flow, and juvenile salmonid survival (Brandes and McLain 2001). Water temperatures in the Sacramento River have limited the survival of young salmon. Juvenile fall-run Chinook salmon survival in the Sacramento River is also directly related with June streamflow and June and July Delta outflow (Dettman *et al*. 1987).

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Hundreds of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, and their tributaries. Although efforts have been made in recent years to screen some of these diversions, many remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile salmonids. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001).

Outmigrant juvenile salmonids in the Delta have been subjected to adverse environmental conditions created by water export operations at the CVP/SWP. Specifically, juvenile salmonid survival has been reduced by the following: (1) water diversion from the mainstem Sacramento River into the central Delta via the Delta Cross Channel (DCC); (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways; (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay; and, (4) increased exposure to introduced, non-native predators such as striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and sunfishes (*Centrarchidae* spp.).

c. *Water Conveyance and Flood Control*

The development of the water conveyance system in the Delta has resulted in the construction of more than 1,100 miles of channels and diversions to increase channel elevations and flow capacity of the channels (Mount 1995). Levee development in the Central Valley affects spawning habitat, freshwater rearing habitat, freshwater migration corridors, and estuarine habitat PCEs. As Mount (1995) indicates, there is an “underlying, fundamental conflict inherent in this channelization.” Natural rivers strive to achieve dynamic equilibrium to handle a watersheds supply of discharge and sediment (Mount 1995). The construction of levees disrupts the natural processes of the river, resulting in a multitude of habitat-related effects.

Many of these levees use angular rock (riprap) to armor the bank from erosive forces. The effects of channelization, and riprapping, include the alteration of river hydraulics and cover along the bank as a result of changes in bank configuration and structural features (Stillwater Sciences 2006). These changes affect the quantity and quality of nearshore habitat for juvenile salmonids and have been thoroughly studied (USFWS 2000, Schmetterling *et al.* 2001, Garland *et al*. 2002). Simple slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators (Stillwater Sciences 2006).

Prior to the 1970s, there was so much debris resulting from poor logging practices that many streams were completely clogged and were thought to have been total barriers to fish migration. As a result, in the 1960s and early 1970s it was common practice among fishery management agencies to remove woody debris thought to be a barrier to fish migration (NMFS 1996). However, it is now recognized that too much large woody debris was removed from the streams resulting in a loss of salmonid habitat and it is thought that the large scale removal of woody debris prior to 1980 had major, long-term negative effects on rearing habitats for salmonids in northern California (NMFS 1996). Areas that were subjected to this removal of large woody debris are still limited in the recovery of salmonid stocks; this limitation could be expected to persist for 50 to 100 years following removal of debris.

Large quantities of downed trees are a functionally important component of many streams (NMFS 1996). Large woody debris influences channel morphology by affecting longitudinal profile, pool formation, channel pattern and position, and channel geometry. Downstream transport rates of sediment and organic matter are controlled in part by storage of this material behind large wood. Large wood affects the formation and distribution of habitat units, provides cover and complexity, and acts as a substrate for biological activity (NMFS 1996). Wood enters streams inhabited by salmonids either directly from adjacent riparian zones or from riparian zones in adjacent non-fish bearing tributaries. Removal of riparian vegetation and IWM from the streambank results in the loss of a primary source of overhead and instream cover for juvenile salmonids. The removal of riparian vegetation and IWM and the replacement of natural bank substrates with rock revetment can adversely affect important ecosystem functions. Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile salmonids. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. The magnitude of these effects depends on the degree to which riparian vegetation and natural substrates are preserved or recovered during the life of the project.

In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney *et al*. 2004). As a result of river narrowing, benthic habitat decreases and the number of macroinvertebrates, such as stoneflies and mayflies, per unit channel length decreases affecting salmonid food supply.

Increased sedimentation resulting from agricultural and urban practices within the Central Valley is a primary cause of salmonid habitat degradation (NMFS 1996). Sedimentation can adversely affect salmonids during all freshwater life stages by: clogging or abrading gill surfaces, adhering to eggs, hampering fry emergence (Phillips and Campbell 1961), burying eggs or alevins, scouring and filling in pools and riffles, reducing primary productivity and photosynthesis activity, and affecting inter-gravel permeability and DO levels. Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival.

d. *Land Use Activities*

Land use activities such as agricultural conversion, and industrial and urban development continue to have large impacts on salmonid habitat in the Central Valley watershed, affecting spawning habitat, freshwater rearing habitat, freshwater migration corridors, estuarine areas, and nearshore marine area PCEs. Until about 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation extending outward for 4 or 5 miles (California Resources Agency 1989). By 1979, riparian habitat along the Sacramento

River diminished to 11,000 to 12,000 acres, or about 2 percent of historic levels (McGill 1987). The CALFED Program (2000) estimated that wetter perimeter reductions in the Delta have decreased from between 25 and 45 percent since 1906. Historically, the San Francisco Estuary included more than 242,000 acres of tidally influenced bay-land habitats and tidal marsh and tidal flats accounted for 98 percent of bay-land habitats. Today only 70,000 acres of tidally influenced habitat remain (CALFED 2000). While historical uses of riparian areas (*e.g.*, wood cutting, clearing for agricultural uses) have substantially decreased, urbanization still poses a serious threat to remaining riparian areas. Riversides are desirable places to locate homes, businesses, and industry. Further, development within the floodplain results in vegetation removal, stream channelization, habitat instability, and point source and non-point source pollution (NMFS 1996). The impacts of riparian vegetation and IWM loss are discussed in section (3) *Water Conveyance and Flood Control.*

In Pacific Northwest and California streams, habitat simplification has lead to a decrease in the diversity of anadromous salmonid species habitat (NMFS 1996). Habitat simplification may result from various land-use activities, including timber harvest, grazing, urbanization and agriculture. Reduction of wood in the stream channel, either from past or present activities, generally reduces pool quantity and quality, alters stream shading which can affect water temperature regimes and nutrient input, and can eliminate critical stream habitat needed for both vertebrate and invertebrate populations. Removal of vegetation also can destabilize marginally stable slopes by increasing the subsurface water load, lowering root strength, and altering water flow patterns in the slope. Constricting channels with culverts, bridge approaches, and streamside roads can reduce stream meandering, partially constrict or channelize flows, reduce pool maintenance, and can preclude passage of anadromous salmonids. Diverse habitats support diverse species assemblages and communities. This diversity contributes to sustained production and provides stability for the entire ecosystem. Further, habitat diversity can also mediate biotic interactions such as competition and predation. Attributes of habitat diversity include a variety and range of hydraulic parameters, abundance and size of wood, and variety of bed substrate (NMFS 1996).

Point source and non-point source pollution occurs at almost every point that urbanization activity influences the watershed. Impervious surfaces (*i.e*. concrete) reduce water infiltration and increase runoff, thus creating greater flood hazard (NMFS 1996). Flood control and land drainage schemes may increase the flood risk downstream by concentrating runoff. A flashy discharge pattern results in increased bank erosion with subsequent loss of riparian vegetation, undercut banks and stream channel widening. Runoff from residential and industrial areas also contributes to water quality degradation (Regional Board 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (Regional Board 1998) that contaminate drainage waters and destroy aquatic life necessary for salmonid survival (NMFS 1996). In addition, juvenile salmonids are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges.

Past mining activities routinely resulted in the removal of spawning gravels from streams, channelization of streams from dredging activities, and leaching of toxic effluents into streams. Many of the effects of past mining operations still impact salmonid habitat today. Current mining practices include suction dredging, placer mining, lode mining, and gravel mining. Present-day mining practices typically are less intrusive than historic operations (hydraulic mining); however, adverse impacts to salmonid habitat still occur as a result of present-day mining activities. Sand and gravel are used for a large variety of construction activities including base material and asphalt, road bedding, drain rock for leach fields, and aggregate mix for buildings and highways.

Most aggregate is derived principally from pits in active floodplains, pits in inactive river terrace deposits, or directly from the active channel. Other sources include hard rock quarries and mining from deposits within reservoirs. Extraction sites located along or in active floodplains present particular problems for anadromous salmonids. Physical alteration of the stream channel may result in the destruction of existing riparian vegetation and the reduction of available area for seedling establishment (Stillwater Sciences 2002). As discussed previously, loss of vegetation impacts riparian and aquatic habitat by causing a loss of the temperature moderating effects of shade and cover, and habitat diversity. Extensive degradation may induce a decline in the alluvial water table, as the banks are effectively drained to a lowered level, affecting riparian vegetation and water supply (NMFS 1996). Altering the natural channel configuration will reduce salmonid habitat diversity by creating a wide, shallow channel lacking in the pools and cover necessary for all life stages of anadromous salmonids. In addition, waste products resulting from past and present mining activities, include cyanide (an agent used to extract gold from ore), copper, zinc, cadmium, mercury, asbestos, nickel, chromium, and lead. These waste products have been found to be toxic to aquatic life, including fish.

e. *Over Utilization*

Ocean Commercial and Sport Harvest: Extensive ocean recreational and commercial troll fisheries for Chinook salmon exist along the Central California coast, and an inland recreational fishery exists in the Central Valley for Chinook salmon and steelhead. Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement. Coded wire tag (CWT) returns indicate that Sacramento River salmon congregate off the California coast between Point Arena and Morro Bay.

Since 1970, the CVI for Sacramento River winter-run Chinook salmon generally has ranged between 0.50 and 0.80. In 1990, when ocean harvest of winter-run Chinook salmon was first evaluated by NMFS and the Pacific Fisheries Management Council (PFMC), the CVI harvest rate was near the highest recorded level at 0.79. NMFS determined in a 1991 biological opinion that continuance of the 1990 ocean harvest rate would not prevent the recovery of Sacramento River winter-run Chinook salmon. Through the early 1990s, the ocean harvest index was below the 1990 level (*i.e.*, 0.71 in 1991 and 1992, 0.72 in 1993, 0.74 in 1994, 0.78 in 1995, and 0.64 in 1996).

Ocean fisheries have affected the age structure of CV spring-run Chinook salmon through targeting large fish for many years and reducing the numbers of 4- and 5-year-old fish (CDFG 1998). Ocean harvest rates of CV spring-run Chinook salmon are thought to be a function of the CVI (Good *et al*. 2005). Harvest rates of CV spring-run Chinook salmon ranged from 0.55 to nearly 0.80 between 1970 and 1995 when harvest rates were adjusted for the protection of Sacramento River winter-run Chinook salmon. The drop in the CVI in 2001 as a result of high fall-run escapement to 0.27 also reduced harvest of CV spring-run Chinook salmon. There is essentially no ocean harvest of steelhead.

Inland Sport Harvest: Historically in California, almost half of the river sportfishing effort was in the Sacramento-San Joaquin River system, particularly upstream from the City of Sacramento (Emmett *et al.* 1991). Since 1987, the Fish and Game Commission (Commission) has adopted increasingly stringent regulations to reduce and virtually eliminate the in-river sport fishery for Sacramento River winter-run Chinook salmon. Present regulations include a year-round closure to Chinook salmon fishing between Keswick Dam and the Deschutes Road Bridge and a rolling closure to Chinook salmon fishing on the Sacramento River between the Deschutes River Bridge and the Carquinez Bridge. The rolling closure spans the months that migrating adult Sacramento River winter-run Chinook salmon are ascending the Sacramento River to their spawning grounds. These closures virtually have eliminated impacts on Sacramento River winter-run Chinook salmon caused by recreational angling in freshwater. In 1992, the Commission adopted gear restrictions (all hooks must be barbless and a maximum of 5.7 cm in length) to minimize hooking injury and mortality of winter-run Chinook salmon caused by trout anglers. That same year, the Commission also adopted regulations which prohibited any salmon from being removed from the water to further reduce the potential for injury and mortality.

In-river recreational fisheries historically have taken CV spring-run Chinook salmon throughout the species' range. During the summer, holding adult CV spring-run Chinook salmon are easily targeted by anglers when they congregate in large pools. Poaching also occurs at fish ladders, and other areas where adults congregate; however, the significance of poaching on the adult population is unknown. Specific regulations for the protection of CV spring-run Chinook salmon in Mill, Deer, Butte, and Big Chico Creeks were added to the existing CDFG regulations in 1994. The current regulations, including those developed for Sacramento River winter-run Chinook salmon, provide some level of protection for spring-run fish (CDFG 1998).

There is little information on steelhead harvest rates in California. Hallock *et al.* (1961) estimated that harvest rates for Sacramento River steelhead from the 1953-1954 through 1958-1959 seasons ranged from 25.1 percent to 45.6 percent assuming a 20 percent non-return rate of tags. The average annual harvest rate of adult steelhead above RBDD for the 3-year period from 1991-1992 through 1993-1994 was 16 percent (McEwan and Jackson 1996). Since 1998, all hatchery steelhead have been marked with an adipose fin clip allowing anglers to distinguish hatchery and wild steelhead. Current regulations restrict anglers from keeping unmarked steelhead in Central Valley streams. Overall, this regulation has greatly increased protection of naturally-produced adult steelhead; however, the total number of CV steelhead contacted might be a significant fraction of basin-wide escapement, and even low catch-and-release mortality may pose a problem for wild populations (Good *et al*. 2005).

f. *Disease and Predation*

Infectious disease is one of many factors that influence adult and juvenile salmonid survival. Salmonids are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environment (NMFS 1996, 1998). Specific diseases such as bacterial kidney disease, *Ceratomyxosis shasta* (C-shasta), columnaris, furunculosis, infectious hematopoietic necrosis, redmouth and black spot disease, whirling disease, and erythrocytic inclusion body syndrome are known, among others, to affect steelhead and Chinook salmon (NMFS 1996, 1998). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases; however, studies have shown that native fish tend to be less susceptible to pathogens than hatchery reared fish. Salmonids may contract diseases that are spread through the water column (*i.e*., waterborne pathogens) as well as through interbreeding with infected hatchery fish.

A fish may be infected yet not be in a clinical disease state with reduced performance. Salmonids typically are infected with several pathogens during their life cycle. However, high infection levels (number of organisms per host) and stressful conditions (crowding in hatchery raceways, release from a hatchery into a riverine environment, high and low water temperatures, *etc*.) usually characterize the system before a disease state occurs in the fish.

Accelerated predation also may be a factor in the decline of Sacramento River winter-run Chinook salmon and CV spring-run Chinook salmon, and to a lesser degree CV steelhead. Human-induced habitat changes such as alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves often provide conditions that both disorient juvenile salmonids and attract predators (Stevens 1961).

On the mainstem Sacramento River, high rates of predation are known to occur at the RBDD, Anderson-Cottonwood Irrigation District's (ACID) diversion dam, GCID's diversion dam, areas where rock revetment has replaced natural river bank vegetation, and at south Delta water diversion structures (*e*.g., Clifton Court Forebay; CDFG 1998). Predation at RBDD on juvenile winter-run Chinook salmon is believed to be higher than normal due to factors such as water quality and flow dynamics associated with the operation of this structure. Due to their small size, early emigrating winter-run Chinook salmon may be very susceptible to predation in Lake Red Bluff when the RBDD gates remain closed in summer and early fall. In passing the dam, juveniles are subject to conditions which greatly disorient them, making them highly susceptible to predation by fish or birds. Sacramento pikeminnow (*Ptychocheilus grandis*) (formerly called Sacramento squawfish) and striped bass congregate below the dam and prey on juvenile salmon in the tail waters. Sacramento pikeminnow is a species native to the Sacramento River basin and has evolved with the anadromous salmonids in this system. However, rearing conditions in the

Sacramento River today (*e.g.*, warm water, low-irregular flow, standing water, and diversions) compared to its natural State and function 70 years ago, are more conducive to warm water species such as Sacramento squawfish and striped bass than native salmonids. Tucker *et al.* (1998) showed that predation during the summer months by Sacramento pikeminnow on juvenile salmonids jumped to 66 percent of total weight of stomach contents. Striped bass showed a strong preference for juvenile salmonids as prey during this study. This research also showed that the percent frequency of occurrence for juvenile salmonids and other fish were nearly equal in stomach contents. Tucker *et al.* (2003) showed the temporal distribution for these two predators in the RBDD area relative to the potential foraging impacts to juvenile salmonids. These researchers stated the importance of flow management to minimize the potential for condensing the concentration of forging areas.

USFWS found that more predatory fish were found at rock revetment bank protection sites between Chico Landing and Red Bluff than at sites with naturally eroding banks (Michny and Hampton 1984). From October 1976 to November 1993, CDFG conducted 10 mark/recapture studies at the SWP's Clifton Court Forebay to estimate pre-screen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 percent to 99 percent. Predation by striped bass is thought to be the primary cause of the loss (Gingras 1997).

Predation on juvenile salmon has increased as a result of water development activities which have created ideal habitats for predators and non-native species. Turbulent conditions near dam bypasses, turbine outfalls, water conveyances, and spillways disorient juvenile steelhead migrants and increase their avoidance response time, thus improving predator success. Increased exposure to predators has also resulted from reduced water flow through reservoirs; a condition which has increased juvenile travel time. Other locations in the Central Valley where predation is of concern include flood bypasses, post-release sites for salmonids salvaged at the Fish Facilities, and the Suisun Marsh Salinity Control Gates (SMSCG). Predation on salmon by striped bass and pikeminnow at salvage release sites in the Delta and lower Sacramento River has been documented (Pickard *et al.* 1982), however, accurate predation rates at these sites are difficult to determine. CDFG conducted predation studies from 1987 to 1993 at the SMSCG to determine if the structure attracts and concentrates predators. The dominant predator species at the SMSCG was striped bass, and the remains of juvenile Chinook salmon were identified in their stomach contents (NMFS 1997).

Although the behavior of salmon and steelhead reduces the potential for any single predator to focus exclusively on them, predation by certain species can be seasonally and locally significant. Changes in predator and prey populations along with changes in the environment, both related and unrelated to development, have been shown to reshape the role of predation (Li *et al.* 1987). Sacramento pikeminnow and striped bass, of the aquatic fish predators, have the greatest potential to negatively affect the abundance of juvenile salmonids. These are large, opportunistic predators that feed on a variety of prey and switch their feeding patterns when spatially or temporally segregated from a commonly consumed prey. Catfish also have the potential to significantly affect the abundance of juvenile salmonids. Prickly (*Cottus asper*) and riffle (*C.*

gulosus) sculpins, and larger salmonids also prey on juvenile salmonids (Hunter 1959; Patten 1962, 1971a, 1971b).

Avian predation on fish contributes to the loss of migrating juvenile salmonids by constraining natural and artificial production. Fish-eating birds that occur in the California Central Valley include great blue herons (*Ardea herodias*), gulls (*Larus spp*.), osprey (*Pandion haliaetus*), common mergansers (*Mergus merganser*), American white pelicans (*Pelecanus erythrorhynchos*), double-crested cormorants (*Phalacrocorax spp*.), Caspian terns (*Sterna caspia*), belted kingfishers (*Ceryle alcyon*), black-crowned night herons (*Nycticorax nycticorax*), Forster's terns (*Sterna forsteri*), hooded mergansers (*Lophodytes cucullatus*) and bald eagles (*Haliaeetus leucocephalus*) (Stephenson and Fast 2005). These birds have high metabolic rates and require large quantities of food relative to their body size.

Mammals may be an important agent of mortality to salmonids in the California Central Valley. Predators such as river otters (*Lutra canadensis*), raccoons (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and western spotted skunk (*Spilogale gracilis*) are common. Other mammals that take salmonid include: badger (*Taxidea taxus*), bobcat (*Linx rufis*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), long-tailed weasel (*Mustela frenata*), mink (*Mustela vison*), mountain lion (*Felis concolor*), red fox (*Vulpes vulpes*), and ringtail (*Bassariscus astutus*). These animals, especially river otters, are capable of removing large numbers of salmon and trout (Dolloff 1993). Mammals have the potential to consume large numbers of salmonids, but generally scavenge post-spawned salmon. Pinnipeds, including harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), and Steller's sea lions (*Eumetopia jubatus*) are the primary marine mammals preying on salmonids (Spence *et al*. 1996). Pacific striped dolphin (*Lagenorhynchus obliquidens*) and killer whale (*Orcinus orca*) also prey on adult salmonids in the nearshore marine environment. Seal and sea lion predation is primarily in saltwater and estuarine environments, although they are known to travel far upstream into freshwater after migrating fish. All of these predators are opportunists, searching out locations where juveniles and adults are most vulnerable.

g. *Climate Change*

On average, the world is about 1.3 °F warmer today than a century ago and the latest computer models predict that, without drastic cutbacks in emissions of carbon dioxide and other gases released by the burning of fossil fuels, the average global surface temperature may raise by two or more degrees in the 21st century (Intergovernmental Panel on Climate Change [IPCC] 2001). Much of that increase will likely occur in the oceans, and evidence suggests that the most dramatic changes in ocean temperature are now occurring in the Pacific (Noakes 1998). Using objectively analyzed data Huang and Liu (2000) estimated a warming of about 0.9 °F per century in the Northern Pacific Ocean.

Summer droughts along the South Pacific coast and in the interior of the northwest Pacific coastlines will mean decreased stream flow in those areas, decreasing salmonid survival and reducing water supplies in the dry summer season when irrigation and domestic water use are greatest. Global warming may also change the chemical composition of the water that fish inhabit: the amount of oxygen in the water may decline, while pollution, acidity, and salinity levels may increase. This will allow for more invasive species to over take native fish species and impact predator-prey relationships (Stachowicz *et al.* 2002, Peterson and Kitchell 2001).

An alarming prediction is the fact that Sierra snow packs are expected to decrease with global warming and that the majority of runoff in California will be from rainfall in the winter rather than from melting snow pack in the mountains (CDWR 2006). This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff.

h. *Artificial Propagation*

Five hatcheries currently produce Chinook salmon in the Central Valley and four of these also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to wild Chinook salmon and steelhead stocks through genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). The genetic impacts of artificial propagation programs in the Central Valley primarily are caused by straying of hatchery fish and the subsequent interbreeding of hatchery fish with wild fish. In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels. For example, Nimbus Hatchery on the American River rears Eel River steelhead stock and releases these fish in the Sacramento River basin. One of the recommendations in the Joint Hatchery Review Report (NMFS and CDFG 2001) was to identify and designate new sources of steelhead brood stock to replace the current Eel River origin brood stock.

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between spring- and fall-run fish have led to the hybridization and homogenization of some subpopulations (CDFG 1998). As early as the 1960s, Slater (1963) observed that early fall- and spring-run Chinook salmon were competing for spawning sites in the Sacramento River below Keswick Dam, and speculated that the two runs may have hybridized. The FRH spring-run Chinook salmon have been documented as straying throughout the Central Valley for many years (CDFG 1998), and in many cases have been recovered from the spawning grounds of fall-run Chinook salmon, an indication that FRH spring-run Chinook salmon may exhibit fall-run life history characteristics. Although the degree of hybridization has not been comprehensively determined, it is clear that the populations of CV spring-run Chinook salmon spawning in the Feather River and counted at RBDD contain hybridized fish.

The management of hatcheries, such as Nimbus Hatchery and FRH, can directly impact spring-run Chinook salmon and steelhead populations by over saturating the natural carrying capacity of the limited habitat available below dams. In the case of the Feather River, significant redd superimposition occurs in-river due to hatchery overproduction and the inability to physically separate spring- and fall-run Chinook salmon adults. This concurrent spawning has led to hybridization between the spring- and fall-run Chinook salmon in the Feather River. At Nimbus Hatchery, operating Folsom Dam to meet temperature requirements for returning hatchery fall-run Chinook salmon often limits the amount if water available for steelhead spawning and rearing the rest of the year.

The increase in Central Valley hatchery production has reversed the composition of the steelhead population, from 88 percent naturally produced fish in the 1950s (McEwan 2001) to an estimated 23 to 37 percent naturally produced fish currently (Nobriga and Cadrett 2001). The increase in hatchery steelhead production proportionate to the wild population has reduced the viability of the wild steelhead populations, increased the use of out-of-basin stocks for hatchery production, and increased straying (NMFS and CDFG 2001). Thus, the ability of natural populations to successfully reproduce and continue their genetic integrity likely has been diminished.

The relatively low number of spawners needed to sustain a hatchery population can result in high harvest-to-escapements ratios in waters where fishing regulations are set according to hatchery population. This can lead to over-exploitation and reduction in the size of wild populations existing in the same system as hatchery populations due to incidental bycatch (McEwan 2001).

i. *Ocean Conditions*

Natural changes in the freshwater and marine environments play a major role in salmonid abundance. Recent evidence suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hare *et al*. 1999). This phenomenon has been referred to as the Pacific Decadal Oscillation. A further confounding effect is the fluctuation between drought and wet conditions in the basins of the American West. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years, which reduced inflows to watersheds up and down the West Coast.

A key factor affecting many West Coast stocks has been a general 30-year decline in ocean productivity. The mechanism whereby stocks are affected is not well understood, partially because the pattern of response to these changing ocean conditions has differed among stocks, presumably due to differences in their ocean timing and distribution. It is presumed that survival in the ocean is driven largely by events occurring between ocean entry and recruitment to a sub-adult life stage.

"El Niño" is an environmental condition often cited as a cause for the decline of West Coast salmonids (NMFS 1996). El Niño is an unusual warming of the Pacific Ocean off South America and is caused by atmospheric changes in the tropical Pacific Ocean (Southern Oscillation-ENSO). El Niño events occur when there is a decrease in the surface atmospheric pressure gradient from the normal-steady trade winds that blow across the ocean from east to west on both sides of the equator. There is a drop in pressure in the east off South America and a rise in the pressure in the western Pacific. The resulting decrease in the pressure gradient across the Pacific Ocean causes the easterly trade winds to relax, and even reverse in some years. When the trade winds weaken, sea level in the western Pacific Ocean drops, and a plume of warm sea water flows from west to east toward South America, eventually reaching the coast where it is reflected south and north along the continents.

El Niño ocean conditions are characterized by anomalous warm sea surface temperatures and changes coastal currents and upwelling. Principal ecosystem alterations include decreased primary and secondary productivity and changes in prey and predator species distributions.

j. *Floods and Droughts*

During flood events, land disturbances resulting from logging, road construction, mining, urbanization, livestock grazing, agriculture, fire, and other uses may contribute sediment directly to streams or exacerbate sedimentation from natural erosive processes (California Advisory Committee on Salmon and Steelhead Trout 1988, NMFS 1996). Sedimentation of stream beds has been implicated as a principle cause of declining salmonid populations throughout their range. In addition to problems associated with sedimentation, flooding can cause scour and redeposition of spawning gravels in typically inaccessible areas. As streams and pools fill in with sediment, flood flow capacity is reduced. Such changes cause decreased stream stability and increased bank erosion, and subsequently exacerbate existing sedimentation problems (NMFS 1996). All of these sources contribute to the sedimentation of spawning gravels and filling of pools and estuaries used by all anadromous salmonids. Channel widening and loss of pool-riffle sequence due to aggradation has damaged spawning and rearing habitat of all salmonids.

k. *Non-native Invasives*

The extensive introduction of non-native fish species has dramatically altered the biological relationships between and among salmonids and the natural communities that share rivers (NMFS 1998). As currently seen in the San Francisco Estuary, non-native fish species can alter the natural food webs that existed prior to their introduction. Perhaps the most significant example is illustrated by the Asiatic freshwater clams *Corbicula fluminea* and *Potamocorbula amurensis*. The arrival of these clams in the estuary disrupted the normal benthic community structure and depressed phytoplankton levels in the estuary due to the highly efficient filter feeding of the introduced clams (Cohen and Moyle 2004). The decline in the levels of phytoplankton reduces the population levels of zooplankton that feed upon them, and hence reduces the forage base available to salmonids transiting the Delta and San Francisco Estuary which feed either upon the zooplankton directly or their mature forms. This lack of forage base can adversely impact the health and physiological condition of these salmonids as they emigrate through the Delta region to the Pacific Ocean.

Attempts to control the non-native fish species also can adversely impact the health and well being of salmonids within the affected water systems. For example, the control programs for the invasive water hyacinth and *Egeria densa* plants in the Delta must balance the toxicity of the herbicides applied to control the plants to the probability of exposure to listed salmonids during herbicide application.

l. *Ecosystem Restoration*

Two programs included under CALFED; the Ecosystem Restoration Program (ERP) and the EWA, were created to improve conditions for fish, including listed salmonids, in the Central Valley. Both actions are well upstream of the project site, but are described here because they were implemented to improve habitat conditions for the listed species that are affected by the BALMD levee repairs. The Restoration actions implemented by the ERP include the installation of fish screens, modification of barriers to improve fish passage, habitat acquisition, and instream habitat restoration. The majority of these actions address key factors affecting listed salmonids and emphasis has been placed in tributary drainages with high potential for CV steelhead and CV spring-run Chinook salmon production. Additional ongoing actions include new efforts to enhance fisheries monitoring and directly support salmonid production through hatchery releases. Recent habitat restoration initiatives sponsored and funded primarily by the CALFED-ERP have resulted in plans to restore ecological function to 9,543 acres of shallow-water tidal and marsh habitats within the Delta. Restoration of these areas primarily involves flooding lands previously used for agriculture, thereby creating additional rearing habitat for juvenile salmonids. Similar habitat restoration is imminent adjacent to Suisun Marsh (*i.e.*, at the confluence of Montezuma Slough and the Sacramento River) as part of the Montezuma Wetlands project, which is intended to provide for commercial disposal of material dredged from San Francisco Estuary in conjunction with tidal wetland restoration.

The CVPIA, implemented in 1992, requires that fish and wildlife get equal consideration with other demands for water allocations derived from the CVP. From this act arose several programs that have benefited listed salmonids: the Anadromous Fish Restoration Program (AFRP), the Anadromous Fish Screen Program (AFSP), and the Water Acquisition Program (WAP). The AFRP is engaged in monitoring, education, and restoration projects geared toward doubling the natural populations of select anadromous fish species residing in the Central Valley. Restoration projects funded through the AFRP include fish passage, fish screening, riparian easement and land acquisition, development of watershed planning groups, instream and riparian habitat improvement, and gravel replenishment. The AFSP combines Federal funding with State and private funds to prioritize and construct fish screens on major water diversions mainly in the upper Sacramento River. The goal of the WAP is to acquire water supplies to meet the habitat restoration and enhancement goals of the CVPIA and to improve the Department of Interior's ability to meet regulatory water quality requirements. Water has been used successfully to improve fish habitat for CV spring-run Chinook salmon and CV steelhead by maintaining or increasing instream flows in Butte and Mill Creeks and the San Joaquin River at critical times.

The U.S. Environmental Protection Agency's Iron Mountain Mine remediation involves the removal of toxic metals in acidic mine drainage from the Spring Creek Watershed with a State-of-the-art lime neutralization plant. Contaminant loading into the Sacramento River from Iron

Mountain Mine has shown measurable reductions since the early 1990s. Decreasing the heavy metal contaminants that enter the Sacramento River should increase the survival of salmonid eggs and juveniles. However, during periods of heavy rainfall upstream of the Iron Mountain Mine, Reclamation substantially increases Sacramento River flows in order to dilute heavy metal contaminants being spilled from the Spring Creek debris dam. This rapid change in flows can cause juvenile salmonids to become stranded or isolated in side channels below Keswick Dam.

The CDWR's Four Pumps Agreement Program has approved approximately $49 million for projects that benefit salmon and steelhead production in the Sacramento-San Joaquin basins and Delta since the agreements inception in 1986. Four Pumps projects that benefit CV spring-run Chinook salmon and steelhead include water exchange programs on Mill and Deer Creeks; enhanced law enforcement efforts from San Francisco Estuary upstream to the Sacramento and San Joaquin Rivers and their tributaries; design and construction of fish screens and ladders on Butte Creek; and, screening of diversions in Suisun Marsh and San Joaquin tributaries. Predator habitat isolation and removal, and spawning habitat enhancement projects on the San Joaquin tributaries benefit steelhead.

The Spring-run Salmon Increased Protection Project provides overtime wages for CDFG wardens to focus on reducing illegal take and illegal water diversions on upper Sacramento River tributaries and adult holding areas, where the fish are vulnerable to poaching. This project covers Mill, Deer, Antelope, Butte, Big Chico, Cottonwood, and Battle Creeks, and has been in effect since 1996. Through the Delta-Bay Enhanced Enforcement Program, initiated in 1994, a team of 10 wardens focus their enforcement efforts on salmon, steelhead, and other species of concern from the San Francisco Estuary upstream into the Sacramento and San Joaquin River basins. These two enhanced enforcement programs have had significant benefits to spring-run Chinook salmon attributed to CDFG, but the results have not been quantified.

The Mill and Deer Creek Water Exchange projects are designed to provide new wells that enable diverters to bank groundwater in place of stream flow, thus leaving water in the stream during critical migration periods. On Mill Creek several agreements between Los Molinos Mutual Water Company (LMMWC), Orange Cove Irrigation District, CDFG, and CDWR allows CDWR to pump groundwater from two wells into the LMMWC canals to pay back LMMWC water rights for surface water released downstream for fish. Although the Mill Creek Water Exchange project was initiated in 1990 and the agreement allows for a well capacity of 25 cubic feet per second (cfs), only 12 cfs has been developed to date. In addition, it has been determined that a base flow of greater than 25 cfs is needed during the April through June period for upstream passage of adult spring-run Chinook salmon in Mill Creek. In some years, water diversions from the creek are curtailed by amounts sufficient to provide for passage of upstream migrating adult spring-run Chinook salmon and downstream migrating juvenile steelhead and spring-run Chinook salmon. However, the current arrangement does not ensure adequate flow conditions will be maintained in all years. CDWR, CDFG, and USFWS have developed the Mill Creek Adaptive Management Enhancement Plan to address the instream flow issues. A pilot project using 1 of the 10 pumps originally proposed for Deer Creek was tested in summer 2003. Future testing is planned with implementation to follow.

2. Critical Habitat

According the NMFS CHART report (2005b) the major categories of habitat-related activities affecting Central Valley salmonids include: (1) irrigation impoundments and withdrawals (2) channel modifications and levee construction, (4) the presence and operation of hydroelectric dams, (5) flood control and streambank stabilization, and (6) exotic and invasive species introductions and management. All of these activities affect PCEs via their alteration of one or more of the following: stream hydrology, flow and water-level modification, fish passage, geomorphology and sediment transport, temperature, DO levels, nearshore and aquatic vegetation, soils and nutrients, physical habitat structure and complexity, forage, and predation. The NMFS CHART gave the Sacramento River Delta a numerical value of 14 out of a possible 18 because, although it is no longer a natural waterway, it is a migratory route that is used by almost all of the adults and juveniles of all the listed species considered in this opinion. The Delta also was determined to need special management considerations to ensure its continued function to support the survival and recovery of listed populations.

3. Southern Distinct Population Segment of North American Green Sturgeon

The principal factors for the decline in the Southern DPS of North American green sturgeon are reviewed in the proposed listing notice (70 FR 17386) and status reviews (Adams *et al*. 2002, NMFS 2005b), and primarily consist of: (1) the present or threatened destruction, modification, or curtailment of habitat or range; (2) poor water quality; (3) over-utilization; (4) increased water temperatures; (5) non-native fish species, and (6), other natural and manmade factors.

a. *Habitat Blockage and Range*

NMFS (2005a) evaluated the ability to rank threats, but concluded that this was not possible due to the lack of information about their impact on the Southern DPS of North American green sturgeon; however, the principle threat considered is the impassible barriers, primarily Keswick and Shasta Dams on the Sacramento River and Feather River that likely block and prevent access to historic spawning habitat (NMFS 2005a). Recent habitat evaluations conducted in the upper Sacramento River for salmonid recovery planning suggests that significant potential green sturgeon spawning habitat was made inaccessible or altered by dams. Historical habitat characteristics, temperature, and geology are summarized by Lindley *et al*. (2006b). This spawning habitat may have extended up into the three major branches of the Sacramento River; the Little Sacramento River, the Pit River system, and the McCloud River (NMFS 2005a). In contrast, recent modeling evaluations by Mora (2006) indicate little or no habitat in the little Sacramento River or the Pit River exists above Shasta dam; however, a considerable amount of habitat exists above Shasta on the mainstem Sacramento River. Green and white sturgeon adults have been observed periodically in the Feather and Yuba Rivers (USFWS 1995, Beamesderfer *et al*. 2004, Jeff McLain, NMFS, pers. comm., 2006) and habitat modeling by Mora (2006) suggests there is sufficient habitat above Oroville Dam. There are no records of larval or juvenile white or green sturgeon; however, there are reports that green sturgeon may reproduce in the Feather River during high flow years (CDFG 2002), but these are unconfirmed. No green sturgeon have been observed in the San Joaquin River; however, the presence of white sturgeon has been documented (USFWS 1995, Beamesderfer *et al*. 2004) making the presence of green sturgeon likely historically as the two species require similar habitat and their ranges overlap in the Sacramento River. Habitat modeling by Mora (2006) also suggests sufficient conditions are present in the San Joaquin River to Friant Dam, and in the Stanislaus, Tuolumne, and Merced Rivers to the dams. In addition, the San Joaquin River had the largest spring-run Chinook salmon population in the Central Valley prior to the construction of Friant Dam (Yoshiyama *et al*. 2001) with escapements approaching 500,000 fish. Thus, it is very possible, based on prior spring-run Chinook salmon distribution and habitat use of the San Joaquin River, that green sturgeon were extirpated from the San Joaquin basin in a similar manner to CV spring-run Chinook salmon. The loss of potential green sturgeon spawning habitat on the San Joaquin River also may have contributed to the overall decline of the Southern DPS of North American green sturgeon.

b. *Water Diversion*

Based on the limited information regarding the size of green sturgeon larvae and nocturnal behavior during their development as well as the high number of diversions on the Sacramento River, it is reasonable to assume the potential threats of water diversions to green sturgeon are relatively high. Under laboratory conditions, green sturgeon larvae cling to the bottom during the day, and move into the water column at night (Van Eenennaam *et al*. 2001). After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al*. 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). At 5 days of age, larvae are approximately 22 mm in total length (Van Eenennaam *et al*. 2001). Based on this information, it is assumed larvae green sturgeon are susceptible to entrainment primarily from benthic water diversion facilities during the first 5 days of development and suseptable to diversion entrainment from facilities drawing water from the bottom and top of the water column when they are exhibiting noctornal behavior (starting at day 6), and at a total length of approximatley 22 mm.

Herren and Kawasaki (2001) documented up to 431 diversions in the Sacramento River between Sacramento and Shasta Dam, most of which were unscreened and of the vertical or slant pump type. Entrainment information regarding larval and post-larval Southern DPS of North American green sturgeon is paltry, as the field identification of green sturgeon larvae is difficult. USFWS staff are working on identification techniques and are optimistic that green sturgeon greater than 40 mm can be identified in the field (Bill Poytress, USFWS, pers. comm. 2006). Captures reported by GCID are not identified to species but are asummed to primarily consist of green sturgeon as white sturgeon are known to spawn primarily between Knights Landing and Colusa (Schaffter 1997). Screens at GCID satisfy both the NMFS and CDFG screening criteria; however, the effectiveness of NMFS and CDFG screen criteria is unknown for sturgeon and there is a possibility that larval and post-larval green sturgeon are taken at GCID. Low numbers of Southern DPS of North American green sturgeon have also been identified and entrained at the Red Bluff Research Pumping Plant (Borthwick *et al*. 1999) and the efficacy of identification and enumeration of entrained post-larval green sturgeon is unknown at this location. The ACID diversion facility also may threaten larval and post-larval Southern DPS of North American green sturgeon as the upstream location of this facility exposes larvae and post-larval stages to entrainment. Information on the entrainment and impacts of this diversion on Southern DPS North American green sturgeon are unknown. Information regarding the impacts of other small scale diversion indicated in Herren and Kawaski (2001) in the Sacramento River is unknown.

Presumably, as green sturegon juveniles grow, they become less suseptable to entrainment as their capacity to excape diversions improve. The majority of Southern DPS North American green sturgeon captured in the Delta and San Francisco Estuary are between 200 and 500 mm (CDFG 2002). Herren and Kawasaki (2001) inventoried water diversions in the Delta finding a total of 2,209 diversions of various types, only 0.7 percent of which were screened. The majority of these diversions were between 12 and 24 inches in diameter, likely with relatively little threat to larger juvenile sturgeon. The largest diversions recorded were those of the Fish Facilities in the south Delta. An unknown portion of the juvenile and adult population is excessively stressed, injured, harassed, or killed by the pumping plants.

Eight large diversions greater than 10 cfs and approximately 60 small diversions between 1-10 cfs exist on the Feather River between the Thermalito Afterbay outlet and the confluence with the Sacramento River (USFWS 1995). No studies to date have specifically addressed sturgeon entrainment on the Feather River; however, studies related to Chinook salmon entrainment at the Sutter Extension Water District's sunrise pumps found significant losses of juvenile salmon (USFWS 1995). Based on potential entrainment problems of green sturgeon elsewhere in the Central Valley and the presence of multiple screened and unscreened diversions in the Feather River, it is assumed that water diversions on the Feather River are a possible threat to juvenile Southern DPS North American green sturgeon.

A significant number of studies have been completed indicating that water exports are a limiting factor on native fish in the Delta (Kjelson *et al*. 1981, Kjelson *et al*. 1990, Meng *et al*. 1994, Meng and Moyle 1995, Arthur *et al*. 1996, Bennett and Moyle 1996, Meng and Matern 2001). CDFG (1992) found a strong correlation between mean daily freshwater outflow (April to July) and white sturgeon year class strength in the Delta (many of the studies concerning sturgeon in the Delta involve the more abundant white sturgeon; however, the threats to green sturgeon are thought to be similar). Additional evidence supporting this relationship was also found when comparing annual production of young sturgeon in the San Francisco Estuary and salvage of young sturgeon at the Skinner Fish Facility between 1968 and 1987 during the months of April and May (CDFG 1992). This association of year class strength with outflow is also found in other anadromous fishes inhabiting the Estuary, such as striped bass, Chinook salmon, American shad, and longfin smelt (Stevens and Miller 1983). It is postulated that these increased outflows could improve survival by transporting dispersing larvae to areas of greater food availability, by dispersing larvae over a wide area of the rivers and San Francisco Estuary to take advantage of all available habitat, by quickly moving larvae downstream of any influence of water diversions in the Delta, or by enhancing productivity in the nursery area by increasing nutrient supply (CDFG 1992). Because of the young-of-the-year (YOY) flow correlation in the Delta exists, it is also assumed to be a factor in tributary flows.

No specific studies of the effects of water diversions on the Southern DPS of North American green sturgeon have been completed to date; however, based on the considerable amount of evidence regarding the effects of diversions on other native fish, including white sturgeon, it is likely that water diversions also impact the Southern DPS of North American green sturgeon.

c. *Water Conveyance*

The impacts of the development of the water conveyance system in the Central Valley have been reviewed in section C: *Factors Affecting the Species and Critical Habitat, Chinook Salmon and Central Valley Steelhead* of this biological option. As mentioned previously, the impacts of channelizing and bank riprapping, include the alteration of river hydraulics and cover along the bank as a result of changes in bank configuration and structural features (Stillwater Sciences 2006), as well as can adversely affect important ecosystem functions. In addition, the armoring and revetment of stream banks tends to narrow rivers, reducing the amount of habitat per unit channel length (Sweeney *et al*. 2004). As a result of river narrowing, benthic habitat decreases and the number of macroinvertebrates, such as stoneflies and mayflies, per unit channel length decreases affecting secondary consumer food supply (fish). Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile fish. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. Information on the lateral dispersion of green sturgeon across channel profiles is limited. Based on the benthic orientation of green sturgeon it is assumed habitat related impacts of channelization and riprapping would primarily consist of ecosystem related impacts, such as food source changes, and altered predator densities. The impacts of channelization and riprapping are though to affect larval, post-larval, juvenile and adult stages of Southern DPS North American green sturgeon, as they are all dependant upon the food web in freshwater for at least a portion of their life cycle.

d. *Migration Barriers*

Adult migration barriers to green sturgeon include structures such as the RBDD, ACID, Sacramento Deep Water Ship Channel locks, Fremont Weir, Sutter Bypass, and DCC Gates. Major physical barriers to adult sturgeon migration on the mainstem Sacramento River are the RBDD and ACID diversion dam (USWFS 1995). Unimpeded migration past RBDD occurs when gates are raised between mid-September and May for winter-run Chinook salmon passage measures. Fish ladders at RBDD are designed for salmonid passage and are used when dam gates are raised; however, improvements to the fish ladders may be possible if they can be designed to emulate the north ladder on Bonneville Dam on the Columbia River, which passes sturgeon successfully (CDFG 2002). Tagging studies by Heublein *et al.* (2006) found a substantial portion of tagged adults failed to pass RBDD prior to May 15 and thus, were unable to access spawning habitat upstream. The fate of the blocked green sturgeon is unknown. The Sacramento River Deep Water Ship Channel connects with the Sacramento River near the Cache Slough confluence above Rio Vista and provides a deepened and straightened channel to West

Sacramento for commercial shipping purposes. A set of locks at the end of the channel at the connection with Sacramento River (in West Sacramento) "blocks the migration of all fish from the deep water ship channel back to the Sacramento River" (CDWR 2003).

Fremont Weir is located at the end of Yolo Bypass, a 40-mile long basin that functions as a flood control outlet. CDWR (2003) indicates that "sturgeon and sometimes salmon are attracted by high flows into the Yolo Bypass basin and then become concentrated behind Fremont Weir." They are then subject to heavy legal and illegal fishing pressure. In addition, field and anecdotal evidence shows that adult green sturgeon migrate up the Yolo Bypass up the toe drain in autumn and winter regardless of Fremont Weir spills (CDWR 2003). The weir is approximately 90 feet long and 5 feet high containing a poorly functioning fish ladder.

Numerous weirs and barriers in the Sutter Bypass known to be passage issues for Chinook salmon also could block sturgeon migration. Sturgeon are attracted to discharges into the toe drains of the Yolo Bypass and subsequently can't re-enter the Sacramento River. In addition, sturgeon attempt to pass over the Freemont weir during flood flows and become stranded behind the flashboards when the flows recede. Though most of these barriers have fish passage structures that work during certain flows (CDWR 2003), they are mostly designed for salmonid passage and would likely block sturgeon.

Upstream migrating adult Chinook salmon are known to utilize the DCC as a migratory pathway (Hallock *et al*. 1970). When the gates are open, Sacramento River water flows into the Mokelumne and San Joaquin Rivers providing migration cues. Attraction to this diverted water is thought to be one of the factors delaying and increasing the straying rate of Chinook salmon (CALFED Science Program 2001, McLaughlin and McLain 2004). In addition to increased travel distances, gate closures can completely block anadromous fish migrations forcing the fish to hold or retrace their routes through the Delta to reach spawning grounds upstream. DCC gate closures typically occur during the winter and early spring months when sturgeon are believed to migrate. Evidence suggests that female sturgeon reabsorb eggs and forgo spawning if prevented from reaching spawning grounds (USFWS 1995). In addition, potential spawning habitat is blocked. Habitat between RBDD and Jelly's Ferry Bridge (RM 267) contains swift current and pools over 20 feet deep as well as contains sand to sand-gravel mixtures found to be preferred by spawning white sturgeon (USFWS 1995, Schaffter 1997, CDFG 2002). Significant evidence exists that green sturgeon prefer similar spawning habitat, yet spawn above white sturgeon spawning areas on the Sacramento River (CDFG 2002).

Exact sturgeon spawning locations in Feather River are unknown; however, based on angler catches, most spawning is believed to occur downstream of Thermalito Afterbay and upstream of Cox's Spillway, just downstream of Gridley Bridge (USFWS 1995). The upstream migration barrier is likely a steep riffle 1 mile upstream of the afterbay outlet with a depth of approximately 6 inches and length of 394 feet. Potential physical barriers to upstream migration include the rock dam associated with Sutter Extension Water District's sunrise pumps, shallow water caused by a head cut at Shanghai Bend, and several shallow riffles between the confluence of Honcut Creek upstream to the Thermalito Afterbay outlet (USFWS 1995). These structures are likely to present barriers to sturgeon during low flows blocking and or delaying migration to spawning habitat.

e. *Poor Water Quality*

Point source and non-point pollution occurs at almost every point that urbanization activity influences the watershed. Impervious surfaces (*i.e*., concrete) reduce water infiltration and increase runoff, thus creating greater flood hazard (NMFS 1996). Flood control and land drainage schemes may increase the flood risk downstream by concentrating runoff. A flashy discharge pattern results in increased bank erosion with subsequent loss of riparian vegetation, undercut banks and stream channel widening. Runoff from residential and industrial areas also contributes to water quality degradation (Regional Board 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (Regional Board 1998) that contaminate drainage waters and destroy aquatic life necessary for steelhead survival (NMFS 1996).

Environmental stresses as a result of low water quality can lower reproductive success and may account for low productivity rates of green sturgeon (Klimley 2002). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Sacramento River (USFWS 1995). Principle sources of organic contamination in the Sacramento River are rice field discharges from Butte Slough, Reclamation District 108, Colusa Basin Drain, Sacramento Slough, and Jack Slough (USFWS 1995). Discharge of rice irrigation water has caused mortality to both *Ceriodaphnia* and fathead minnows in the Sacramento River and it is believed that rice field discharges in May and June could affect sturgeon larvae survival (USFWS 1995). No specific information is available on contaminant loads or impacts to green sturgeon, however, the difference in distribution of green and white sturgeon (ocean migrants vs. estuarine inhabitants) probably makes green sturgeon less vulnerable than white sturgeon to bioaccumulation of contaminants found in the estuary (CDFG 2002).

High levels of trace elements can also decrease sturgeon early life-stage survival, causing abnormal development and high mortality in yolk-sac fry sturgeon at concentrations at the levels of parts per billion (Dettlaff *et al.* 1981, as referenced in USFWS 1995). Water discharges from Iron Mountain Mine have affected survival of fish downstream of Keswick Dam and storage limitations and limited availability of dilution flows cause downstream copper and zinc levels to exceed salmonid tolerances (USFWS 1995). Although the impact of trace elements on Southern DPS of North American green sturgeon production is not completely understood, negative impacts are suspected (USFWS 1995).

Organic contaminants from agricultural returns, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Feather River (USFWS 1995). Feather River water collected at Verona on May 27 and June 5, 1987, resulted in 50 and 60 percent mortality in *Ceriodaphnia* and fathead minnow bioassays, respectively. Similar effects were also found in the Feather River in 1988 and 1989 (Regional

Board, 1991, as cited in USFWS 1995). Toxic effects were attributed to organic contaminants in rice irrigation water released into Jack Slough and into Honcut Creek and Bear River to a lesser degree. Elevated levels of arsenic, chromium, copper, and mercury exceeding median international standards were found in various fish species in the Feather River between 1978 and 1987.

f. *Over Utilization and Poaching*

Commercial harvest for green sturgeon occurs primarily along the Oregon and Washington coasts and within their coastal estuaries (Jeff McLain, NMFS, pers. comm., 2006). Green sturgeon also have been incidentally captured in the California set-net fishery in southern California. Adams *et al*. (2002) reported harvest of green sturgeon from California, Oregon, and Washington between 1985 and 2001. Total captures of green sturgeon in the Columbia River Estuary by commercial means ranged from 240 fish per year to 6,000. Catches in Willapa Bay and Grays Harbor by commercial means combined ranged from 9 fish to 2,494 fish per year. Emmett *et al*. (1991) indicated that an average of 4.7 to 15.9 tons of green sturgeon were landed annually in Grays Harbor and Willapa Bay respectively. Overall, captures appear to be dropping through the years; however, this could be related to changing fishing regulations. Adams *et al*. (2002) also reported sport fishing captures in California, Oregon, and Washington. Within the San Francisco Estuary, green sturgeon are captured by sport fisherman targeting the more desirable white sturgeon, particularly in San Pablo and Suisun bays (Emmett *et al*. 1991). While no sport fishing captures can be attributed to California as all green sturgeon captured are captured incidentally, sport fishing in the Columbia River, Willapa Bay, and Grays Harbor captured from 22 to 553 fish per year between 1985 and 2001. Again, it appears sport fishing captures are dropping through time; however, it is not known if this is a result of abundance, changed fishing regulations, or other factors. Based on new research by Israel (2006) and past tagged fish returns reported by CDFG (2002), a high proportion of green sturgeon present in the Columbia River, Willapa Bay, and Grays Harbor (as much as 80 percent in the Columbia River) may be Southern DPS North American green sturgeon. This indicates a potential threat to the Southern DPS North American green sturgeon population.

Due to slot limits imposed on the sport fishery by the CDFG, only white sturgeon between 46 and 72 inches may be retained by sport fisherman with a daily bag limit of 1 fish in possession. Currently under emergency fishing regulations, all green sturgeon are to be returned to the water. CDFG (2002) indicates high sturgeon vulnerability to the fishery in areas where sturgeon are concentrated, such as the Delta to San Pablo Bay area in late winter and the upper Sacramento River during the spawning migration. In addition, the trophy status of white sturgeon and the consequent incentive for retaining oversize (>183 cm) fish is another impetus for active enforcement of sturgeon angling regulations (CDFG 2002).

Poaching rates on the Feather River are unknown; however, catches of sturgeon occur during all years, especially during wet years. There are no catch, effort, and stock size data precluding exploitation estimates (USFWS 1995). Areas just downstream of Thermalito Afterbay outlet and

Cox's Spillway, and several barriers impeding migration may be areas of high adult mortality from increased fishing effort and poaching.

Poaching rates on the San Joaquin River are unknown; however, catches of sturgeon occur during all years, especially during wet years. There are no catch, effort, and stock size data precluding exploitation estimates. What is known, is that the small population of sturgeon inhabiting the San Joaquin River experiences heavy fishing pressure, particularly illegal snagging, and it may be more than the population can support (USFWS 1995).

g. *Increased Water Temperature*

Water temperatures greater than 63 ºF can increase sturgeon egg and larval mortality (Pacific States Marine Fisheries Commission 1992). Temperatures near RBDD on the Sacramento River historically occur within optimum ranges for sturgeon reproduction; however, temperatures downstream of RBDD, especially later in the spawning season, were reported to be frequently above 63 ºF (USFWS 1995). High temperatures in the Sacramento River during the February to June period no longer appear to be a concern as temperatures in the upper Sacramento River are actively managed for Sacramento River winter-run Chinook salmon, and the Shasta temperature curtain device installed at Shasta Dam in 1997 appears to maintain cool water conditions. A review of temperatures at RBDD during May and June between the years of 1995 and 2004 found no daily temperatures greater than 60 ºF (California Data Exchange Center preliminary data, RBDD daily water temperature data).

Approximately 5 miles downstream of Oroville Dam, water is diverted at the Thermalito Diversion Dam, into the Thermalito Power Canal, thence to the Thermalito Forebay and another powerhouse and finally into the Thermalito Afterbay. The Oroville-Thermalito Complex provides water conservation, hydroelectric power, recreation, flood control, and fisheries benefits. The reach of the Feather River downstream of Oroville Dam to the Thermalito Diversion Dam is often referred to as the "low-flow" river section and maintains a constant 600 cfs. Thus, water temperatures downstream of the Thermalito Afterbay outlet are considerably higher than temperatures in the low-flow channel (USFWS 1995). It is likely that high water temperatures (greater than 63 ºF) may deleteriously affect sturgeon egg and larval development, especially for late-spawning fish in drier water years (USFWS 1995). CDFG (2002) also indicated water temperatures may be inadequate for spawning and egg incubation in the Feather River during many years as the result of releases of warmed water from Thermalito Afterbay. They believed that this may be one reason neither green nor white sturgeon are found in the river in low-flow years. It is not expected that water temperatures will become more favorable in the near future (CDFG 2002) and this temperature problem will continue to be a threat.

The lack of flow in the San Joaquin River as a result of Friant Dam operations and agricultural return flows also contributes to higher temperatures in the mainstem San Joaquin River offering less water to keep temperatures cool for anadromous fish. Temperatures directly affect survival, growth rates, distribution, and development rates of anadromous fish. In addition, temperatures indirectly affect growth rate, distribution, and development rate of anadromous fish (Myrick and

Cech 2004). Though these effects are difficult to measure, temperatures in the lower San Joaquin River continually exceed preferred temperatures for sturgeon migration and development during spring months. Optimal temperatures for egg and larval survival of white sturgeon are between 50 and 63 ºF and survival at early-developmental stages is severely reduced at temperatures greater than 68 ºF (USFWS 1995). CDFG indicates water temperatures during May when Vernalis flow is less than 5,000 cfs were at levels causing chronic stress in juvenile Chinook salmon (Reynolds *et al*. 1993). Temperatures at Stevenson on the San Joaquin River near Merced River confluence on May 31 between 2000 and 2004 ranged from 77.2 to 81.7 ºF (California Data Exchange Center, preliminary data). Juvenile sturgeon are exposed to increased water temperatures in the Delta during the late spring and summer due to the loss of riparian shading, and by thermal inputs from municipal, industrial, and agricultural discharges. High water temperatures on the San Joaquin River and in the Delta are likely a threat to the Southern DPS of North American green sturgeon.

h. *Non-native Invasives*

Green sturgeon have most likely been impacted by non-native fish species introductions resulting in changes in trophic interactions in the Delta. Many of the recent introductions of invertebrates have greatly affected the benthic fauna in the Delta and bays. CDFG (2002) reviewed many of the recent non-native fish species introductions and the potential consequences to green sturgeon. Most notable species responsible for altering the trophic system of the Sacramento-San Joaquin Estuary include the overbite clam, the Chinese mitten crab, the introduced mysid shrimp (*Acanthomysis bowmani)*, and another introduced isopod (*Gammarus* sp). Likewise, introductions of invasive plant species such as the water hyacinth (*Eichhornia crassipes*) and *Egeria densa* have altered nearshore and shallow water habitat by raising temperatures and inhibiting access to shallow water habitat. *Egeria densa* forms thick "walls" along the margins of channels in the Delta. This growth prevents juvenile native fish from accessing their preferred shallow water habitat along the channel's edge. Water hyacinth creates dense floating mats that can impede river flows and alter the aquatic environment beneath the mats. DO levels beneath the mats often drop below sustainable levels for fish due to the increased amount of decaying vegetative matter produced from the overlying mat. Like *Egeria*, water hyacinth is often associated with the margins of the Delta waterways in its initial colonization, but can eventually cover the entire channel if conditions permit. This level of infestation can produce barriers to anadromous fish migrations within the Delta. The introduction and spread of *Egeria* and water hyacinth have created the need for aquatic weed control programs that utilize herbicides targeting these species. The effects of these herbicides on green sturgeon are similar to salmon, and include bioaccumulation, and mortality to eggs and larvae.

i. *Dredging*

Hydraulic dredging is a common practice in the Delta and San Francisco Estuary to allow commercial and recreational vessel traffic. Such dredging operations use a cutterhead dredge pulling water upwards through intake pipelines, past hydraulic pumps, and down outflow pipelines to disposal sites placing bottom oriented fish such as North American green sturgeon at risk. Studies by Buell (1992) reported approximately 2,000 sturgeon entrained in the removal of one million tons of sand from the bottom of the Columbia River at depths of 60-80 feet. In addition, dredging operations can elevate toxics such as ammonia, hydrogen sulfide, and copper (NMFS 2006). Other factors include bathymetry changes and acoustic impacts (NMFS 2006).

j. *Climate Change*

The potential effects of climate change on the listed salmonids were discussed in the *Chinook Salmon and Central Valley Steelhead* section and primarily consist of altered ocean temperatures and stream flow patterns in the Central Valley. Changes in Pacific Ocean temperatures can alter predator prey relationships and affect migratory habitat of the Southern DPS of North American green sturgeon. Increases in rainfall and decreases in snow pack in the Sierra Nevada range will affect cold-water pool storage in reservoirs affecting river temperatures. As a result, the quantity and quality of water that may be available to the Southern DPS of North American green sturgeon will likely significantly decrease.

k. *Conservation Measures*

The AFRP specifically applies the doubling effort toward Chinook salmon, CV steelhead, striped bass, and white and green sturgeon. Though most efforts of the AFRP have primarily focused on Chinook salmon as a result of their listing history and status, the Southern DPS of North American green sturgeon may receive some unknown amount of benefit from these restoration efforts. For example, the acquisition of water for flow enhancement on tributaries to the Sacramento River, fish screening for the protection of Chinook salmon and CV steelhead, or riparian revegetation and instream restoration projects would likely have some ancillary benefits to the Southern DPS. The AFRP has also invested in one green sturgeon research project that has helped improve our understanding of the life history requirements and temporal patterns of the of the Southern DPS of North American green sturgeon.

Many notable beneficial actions have originated and been funded by the CALFED program including such projects as floodplain and instream restoration, riparian habitat protection, fish screening and passage projects, research regarding non-native fish species and contaminants, restoration methods, and watershed stewardship and education and outreach programs. Prior Federal Register notices have reviewed the details of CVPIA and CALFED programs and potential benefits towards anadromous fish, particularly Chinook salmon and CV steelhead (50 CFR 33102). Projects potentially benefiting North American green sturgeon primarily consist of fish screen evaluation and construction projects, restoration evaluation and enhancement activities, contaminations studies, and DO investigations related to the San Joaquin River Deep Water Ship Channel. Two evaluation projects specifically addressed green sturgeon while the remaining projects primarily address listed salmonids and fishes of the area in general. The new information from research will be used to enhance our understanding of the risk factors affecting recovery thereby improving our ability to develop effective management measures.

IV. ENVIRONMENTAL BASELINE

The environmental baseline "includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process" (50 CFR §402.02).

Historically, as water from the Sacramento River entered the Delta area it would naturally change its course as it meandered toward San Francisco Bay. The course changes were dictated by size of the flows, the land elevations, erosion and a broad range of other naturally occurring dynamics. As the surrounding lands were developed into farms, urban, and suburban areas, it became advantageous to confine the flowing water to a prescribed system of channels; levees were built along the channel banks to assure that flows would stay within those channels. The land surrounding the Sacramento River Delta now has a lower elevation than the water surface of the channels, and failure of the levees would lead to wide-spread flooding and damage to the adjacent land developments. To prevent that, the levees are armored with reinforcing materials whenever they show signs of weakness. This has been going on for years, and the repairs have been accomplished by individual land-owners, levee maintenance districts, and government institutions at all levels. Some of the repairs are primitive and some well-designed, but because most of the levees were originally built out of sand dredged from the river bottom, they are inherently weak, and the need to repair them is an ongoing challenge. Currently, 100 percent of the channel banks in the Brannan-Andrus Island action area are levees; over 95 percent have undergone repair since originally constructed.

Numerous studies, many of which are cited in this opinion, have demonstrated that removal of woody material, shading, and natural riparian vegetation from riverbanks is detrimental to the listed species covered in this opinion. However, the action area (the Sacramento River Delta) was one of the earliest reaches of the river system to undergo these changes, and the runs of anadromous salmon continued for many years to be robust in spite of it. However, in recent decades, the cumulative effects of changes to the river system (dams, diversions, channelization, to name a few) have caused populations of anadromous species to decline. The action area is primarily a migration route for adults returning from the Pacific Ocean to spawn upstream in the Sacramento and its tributaries, and for the juveniles that are migrating seaward to pass on their journey. It is likely that some of the smolts require refuge areas as they migrate. There are few of those now in the action area. These listed species have had to contend with massive changes to the river system in which they evolved. The channelization of the Delta is but one of them.

A. Status of the Species and Critical Habitat in the Action Area

1. Status of the Species Within the Action Area

The action area functions as a migratory corridor for adult Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead, and provides migration and rearing habitat for juveniles of these species. A large proportion of all Federally listed Central Valley salmonids are expected to utilize aquatic habitat within the action area. The action area also functions as a migratory and holding corridor for adults, and rearing and migratory habitat for juveniles of the Southern DPS of North American green sturgeon.

a. *Sacramento River Winter-run Chinook Salmon*

Sacramento River winter-run Chinook salmon are currently only present in the Sacramento River below Keswick Dam, and are composed of a single breeding population (*Status of the Species and Critical Habitat* section). The entire population of migrating adults and emigrating juveniles must pass through the action area.

A detailed assessment of the migration timing of Sacramento River winter-run Chinook salmon was reviewed in the *Status of the Species and Critical Habitat* section. Adult Sacramento River winter-run Chinook salmon are expected to be present in the Sacramento River portion of the action area between November and June (Myers *et al*. 1998, Good *et al*. 2005) as they migrate to spawning grounds. Juvenile Sacramento River winter-run Chinook salmon migration patterns in the Sacramento River and Steamboat Slough can best be described by temporal migration characteristics found by the USFWS (2001) in beach seine captures along the lower Sacramento River between Sacramento and Princeton, and in the Delta south of Sacramento along the Sacramento River, and in nearby channels such as Steamboat and Georgiana sloughs. Because beach seining samples the shoreline rather than the center of the channel as is often the case in rotary screw traps and trawls, it is considered the most accurate sampling effort in predicting the nearshore presence of juvenile salmonids. In the Sacramento River, between Princeton and Sacramento, juveniles are expected between September and mid April, with highest densities between December and March (USFWS 2001). Delta captures were similar, but slightly later as they are downstream; juveniles are expected between November and mid April with highest densities between December and February. Rotary screw trap work at Knights Landing on the Sacramento River by Snider and Titus (2000) captured juveniles between August and April, with heaviest densities observed first during November and December, and second during January through March. The presence of juvenile Sacramento River winter-run Chinook salmon in Steamboat slough is dependant on hydrologic conditions and the species exposure to them in the north Delta (Jeff McLain, NMFS, pers. comm., 2006). For example, the operation of the DCC gates affects Sacramento River flow entering Steamboat Slough increasing salmonid diversions into Steamboat Slough. In most cases, past catches of Sacramento River winter-run Chinook salmon juveniles in Steamboat sloughs have been relatively low (Jeff McLain, NMFS, pers. comm., 2006).

b. *Central Valley Spring-run Chinook Salmon*

CV spring-run Chinook salmon populations currently spawn in the Sacramento River below Keswick Dam, the low-flow channel of the Feather River, and in Sacramento River tributaries including Mill, Deer, Antelope, and Butte Creeks (CDFG 1998). The entire population of migrating adults and emigrating juveniles must pass through the action area.

A detailed assessment of the migration timing of CV spring-run Chinook salmon was reviewed in the *Status of the Species and Critical Habitat* section. Adult CV spring-run Chinook salmon are expected on the Sacramento River between March and July (Myers *et al*. 1998, Good *et al*. 2005). Peak presence is believed to be during February and March (CDFG 1998). In the Sacramento River, juveniles may begin migrating downstream almost immediately following emergence from the gravel with most emigration occurring from December through March (Moyle *et. al.* 1989, Vogel and Marine 1991). Snider and Titus (2000) observed that up to 69 percent of spring-run Chinook salmon emigrate during the first migration phase between November and early January. The remainder of the CV spring-run Chinook salmon emigrate during subsequent phases that extend into early June. The age structure of emigrating juveniles is comprised of YOY and yearlings. The exact composition of the age structure is not known, although populations from Mill and Deer Creek primarily emigrate as yearlings (Colleen Harvey-Arrison, CDFG, pers. comm., 2004), and populations from Butte Creek primarily emigrate as fry (Ward *et. al.* 2002). Younger juveniles are found closer to the shoreline than older individuals (Healey 1991). As is the case for Sacramento River winter-run Chinook salmon, the presence of juvenile CV spring-run Chinook salmon in Steamboat slough is dependant on hydrologic conditions and the species exposure to them in the north Delta (Jeff McLain, NMFS, pers. comm., 2006). In most cases, past catches of CV spring-run Chinook salmon juveniles in Steamboat slough have been relatively low (Jeff McLain, NMFS, pers. comm., 2006).

c. *Central Valley Steelhead*

CV steelhead populations currently spawn in tributaries to the Sacramento and San Joaquin Rivers. The proportion of steelhead in this DPS that migrate through the action area is unknown. However, because of the relatively large amount of suitable habitat in the Sacramento River relative to the San Joaquin River, it is probably high. Adult steelhead may be present in all parts of the action area from June through March, with the peak occurring between August and October (Bailey 1954, Hallock *et al.* 1957). Highest abundance of adults and juveniles is expected in the Sacramento River part of the action area. Juvenile steelhead emigrate through the Sacramento River from late fall to spring. Snider and Titus (2000) observed that juvenile steelhead emigration primarily occurs between November and May at Knights Landing. The majority of juvenile steelhead emigrate as yearlings and are assumed to be primarily utilizing the center of the channel rather than the shoreline.

d. *Southern DPS of North American Green Sturgeon*

The spawning population of the Southern DPS of North American green sturgeon is currently restricted to the Sacramento River below Keswick Dam, and is composed of a single breeding population (*Status of the Species and Critical Habitat* section), thus the entire population of adults and juveniles must pass through the action area.

A detailed assessment of the migration timing and life history of the Southern DPS of North American green sturgeon was reviewed in the *Status of the Species and Critical Habitat* section. Adult Southern DPS of North American green sturgeon migrate upstream through the action area primarily between March and June (Adams *et al*. 2002). Larva and post-larvae are present on the lower Sacramento River between May and October, primarily during June and July (CDFG 2002). Small numbers of juvenile Southern DPS of North American green sturgeon have been captured at various locations on the Sacramento River as well in the Delta (in the action area downstream of Sacramento) during all months of the year (IEP Database, Borthwick *et al*. 1999).

2. <u>Status of Critical Habitat Within the Action Area</u>

a. *Sacramento River winter-run Chinook salmon, Central Valley Steelhead and Central Valley spring-run Chinook Salmon*

The action area is within designated critical habitat for Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead. Habitat requirements for these species are similar. The PCEs of salmonid habitat within the action area include: freshwater rearing habitat, freshwater migration corridors, and estuarine areas, containing adequate substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food; riparian vegetation, space, and safe passage conditions. Habitat within the action area is primarily used as freshwater rearing and migration and as freshwater migration for adults. The condition and function of this habitat has been impaired through several factors discussed in the *Status of the Species and Habitat* section of this biological opinion. The result has been the reduction in quantity and quality of several essential elements of migration habitat required by juveniles to grow, and survive. The essential element and consequent value of the action area is that it is a migration corridor. NMFS believes that the current lack of rearing habitat does degrade its condition, but owing to the action area's proximity to the ocean, most migrating fish are not likely looking for refuge areas as they pass the site. In spite of the current degraded condition of this habitat, NMFS considers the value of this area for the conservation of the species to be high because its entire length is used for migration during extended periods of time by a large proportion of all Federally listed anadromous fish species in the Central Valley. NMFS considers an area to be of high conservation value, regardless of its current condition, where conservation of the area's habitat PCEs are highly valuable to the ESUs that depend on that area.

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted streamflows and altered the natural cycles in which juvenile and adult salmonids have evolved. Changes in streamflows and diversions of water affect freshwater rearing habitat and freshwater migration corridor PCEs in the action area. Various land-use activities in the action area such as urbanization and agricultural encroachment have resulted in habitat simplification. Runoff from residential and industrial areas also contributes to water quality degradation (Regional Board 1998). Urban stormwater runoff contains pesticides, oil, grease, heavy metals, polynuclear aromatic hydrocarbons, other organics and nutrients (Regional Board 1998) that contaminate drainage waters and destroy aquatic life necessary for salmonid survival (NMFS 1996). In addition, juvenile salmonids are exposed to increased water temperatures as a result of thermal inputs from municipal, industrial, and agricultural discharges in the action area. Accelerated predation as a result of habitat changes in the action area, such as the alteration of natural flow regimes and the installation of bank revetment structures such as dams, bridges, water diversions, and piers are likely a factor in the decline of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead.

Within the action area, the freshwater rearing and migration PCEs have been transformed from a meandering waterway lined with a dense riparian corridor, to a highly leveed system under varying degrees of control over riverine erosional processes and flooding.

3. Southern Distinct Population Segment of North American Green Sturgeon

The action area is utilized by the Southern DPS of North American green sturgeon adults for holding and migration purposes. North American green sturgeon holding habitat consists of the bottoms of deep pools where velocities are lowest often in off-channel coves or low-gradient reaches of the main channel (Erickson *et al*. 2002). Erickson *et al*. (2002) also found that in the Rogue River many of these sites were also found close to sharp bends.

The diversions on the Sacramento River and in the north Delta are a potential threat to the Southern DPS of North American green sturgeon. It is assumed larval green sturgeon are susceptable to entrainment primarily from benthic water diversion facilities during the first 5 days of development and suseptable to diversion entrainment from facilities drawing water from the bottom and top of the water column when they are exhibiting noctornal behavior (starting at day 6). Reduced flows in the action area likely affect year class strength of the Southern DPS of North American green sturgeon as increased flows have been found to improve year class strength. Adult migration barriers near the action area include the Sacramento Deep Water Ship Channel locks, Fremont Weir, and DCC Gates. These barriers can delay migration of Southern DPS North American green sturgeon affecting reproductive capacity and general health. Various land-use activities in the action area such as urbanization and agricultural encroachment have resulted in habitat simplification. Runoff from residential and industrial areas also contributes to water quality degradation (Regional Board 1998).

The transformation of the Sacramento River from a meandering waterway lined with dense riparian corridor, to a highly leveed system under varying degrees of control over riverine erosional processes resulted in homogenization of the river, including effects to the rivers sinuosity (USFWS 2000). In addition, the change in the ecosystem as a result of the removal of riparian vegetation and IWM likely impacted potential prey items and species interaction that green sturgeon would experience while holding. The effects of channelization on upstream migration of green sturgeon are unknown.

The Sacramento River is utilized by larvae and post-larvae and to a lesser extent, juvenile Southern DPS of North American green sturgeon for rearing and migration purposes. Although it is believed that larvae and post-larvae as well as juveniles primarily are benthic (with the exception of the post-larvae nocturnal swim-up believed to be a dispersal mechanism), the massive channelization effort in the action area has resulted in a loss of ecosystem properties (USFWS 2000, Sweeney *et al*. 2004). Channelization results in reduced food supply (aquatic invertebrates), and reduced pollutant processing, organic matter processing, and nitrogen uptake (Sweeney *et al*. 2004).

B. Factors Affecting the Species and Habitat in the Action Area

Because the action area is in the migratory route of the Sacramento River winter-run and CV spring-run Chinook salmon ESUs, and the CV steelhead DPS as well as the Southern DPS of North American green sturgeon, many of the factors affecting the species are discussed in the *Status of the Species and Habitat section* of this biological opinion. This section will focus on portions of the action area that are most relevant to the general location of the proposed action.

1. <u>Sacramento River Winter-run Chinook Salmon, Central Valley Steelhead, and Spring-run Chinook Salmon</u>

The magnitude and duration of peak flows during the winter and spring are reduced by water impoundment in upstream reservoirs affecting listed salmonids in the action area. Instream flows during the summer and early fall months have increased over historic levels for deliveries of municipal and agricultural water supplies. Overall, water management now reduces natural variability by creating more uniform flows year-round. Current flood control practices require peak flood discharges to be held back and released over a period of weeks. Consequently, the mainstream of the river often remains too high and turbid to provide quality rearing habitat. High water temperatures also limit habitat availability for listed salmonids in the lower Sacramento River. High summer water temperatures in the lower Sacramento River can exceed 72 ^{o}F, and create a thermal barrier to the migration of adult and juvenile salmonids (Kjelson *et al*. 1982). In addition, water diversions, for agricultural and municipal purposes have reduced river flows and increased temperatures during the critical summer months limiting the survival of juvenile salmonids (Reynolds *et al*. 1993). Impacts to adult migration present in the action area, such as migration barriers, water conveyance factors, and water quality, non-native fish species, commercialization, *etc.*, are discussed in the *Status of Species and Critical Habitat* section.

Levee construction and bank protection have affected salmonid habitat availability and the processes that develop and maintain preferred habitat by reducing floodplain connectivity, changing riverbank substrate size, and decreasing riparian habitat and SRA. Individual bank protection sites for this project are in the range of few hundred linear feet in length. Such bank protection generally results in two levels of impacts to the environment: (1) site-level impacts which affect the basic physical habitat structure at individual bank protection sites; and (2) reach-level impacts which are the accumulative impacts to ecosystem functions and processes that accrue from multiple bank protection sites within a given river reach (USFWS 2000). Revetted embankments result in loss of sinuosity and braiding and reduce the amount of aquatic habitat.

Impacts at the reach level result primarily from halting erosion and controlling riparian vegetation. Reach-level impacts which cause significant impacts to fish are reductions in new habitats of various kinds, changes to sediment and organic material storage and transport, reductions of lower food-chain production, and reduction in IWM.

The use of rock armoring limits recruitment of IWM (*i.e.*, from non-riprapped areas), and greatly reduces, if not eliminates, the retention of IWM once it enters the river channel. Riprapping creates a relatively clean, smooth surface which diminishes the ability of IWM to become securely snagged and anchored by sediment. IWM tends to become only temporarily snagged along riprap, and generally moves downstream with subsequent high flows. Habitat value and ecological functioning aspects are thus greatly reduced, because wood needs to remain in place to generate maximum values to fish and wildlife (USFWS 2000). Recruitment of IWM is limited to any eventual, long-term tree mortality and whatever abrasion and breakage may occur during high flows (USFWS 2000). Juvenile salmonids are likely being impacted by reductions, fragmentation, and general lack of connectivity of remaining nearshore refuge areas.

The Corp's SRBPP constructed bank protection projects at RM 149 in 2001 and 56.7 in 2004. The RM 149 project included conservation measures recommended by NMFS and the USFWS to remove the jeopardizing effects of the action constructing a set-back levee, or other conservation measures identified by the IWG that create or restore floodplain habitats, create additional riparian habitat, increase IWM recruitment, or improve the growth and survival of listed salmon and steelhead in the action area. The biological opinion required Corps to initiate a programmatic consultation for the SRBPP and to develop a comprehensive aquatic monitoring and evaluation program. The RM 56.7 project reaffirmed the commitment to implement conservation measures at RM 149, and described similar measures to minimize the effects of construction at RM 56.7. The RM 56.7 project also identified a timeline for implementing the conservation measures. As a result, off-site mitigation will be implemented on the right (*i.e.*, north) bank of the Lower American River, 0.5 miles above the confluence with the Sacramento River, and at a site on the Sacramento River, near RM 81. The Corps currently is drafting a draft biological assessment for NMFS to review prior to requesting a formal programmatic consultation. The Corps is committed to a comprehensive monitoring plan implementation in 2008. The Corps has awarded contracts for project-specific monitoring for 2007 to Stillwater Sciences until a plan can be developed in cooperation with CDWR. The current plan awarded to Stillwater Sciences addresses monitoring at all SRBPP sites constructed since 2001. The Corps will issue a request for proposals for 5 years of monitoring by July 1, 2007.

The Lower American River compensation project length is approximately 1,000 feet, the width varies from 0 to 300 feet measured from the edge of the river, and the project footprint is approximately 4 acres. This reach of the lower American River was substantially altered by the massive amounts of sediment deposited as a result of hydraulic mining in the upper watershed. The result is an elevated floodplain that has significantly altered the natural relationship between the river and the surrounding floodplain. The desirable vegetation communities are not reproducing and the floodplain is rarely available to fish. The Corps has issued a design contract, and construction will be initiated during 2007. The predominant project feature would be a large graded bench with an elevation range between 4 and 12 feet covering approximately a 2.0 acre area. The majority of this area is between elevation 5 and 9 feet. These elevations are designed to produce shallow inundation at average spring and winter river stages of 8 feet and 9.5 feet, respectively. The bench area grading includes two sloping depressions that are designed with inlets from the main channel to facilitate full drainage of the project site and reduce the risk of stranding fish during the transition to very low water river stages. Overall, the site will support a broad range of riparian habitat, providing a thick band of vegetation near the river and a less dense and varied palette over the rest of the project footprint. The design also includes the incorporation of IWM to provide enhanced fish cover along the bank and brush mattresses to control erosion. A distribution of relatively level benches at various elevations will provide shallow water for diverse salmonid rearing opportunities at target river stages. Preliminary SAM modeling for conceptual designs shows that the American River site will provide extensive habitat value that may fully compensate for the habitat losses at RM 149, and 56.7.

The Sacramento RM 82 site also offers opportunities for offsite mitigation if the American River site does not provide full compensation as to be determined through SAM modeling. The Corps is coordinating with CDWR to complete the real estate negotiations associated with acquiring the property. Once this is complete, a habitat restoration and enhancement project will be designed to compensate for past, and possibly future bank protection projects, as necessary.

The objectives of the lower American River restoration are to restore natural habitats that will benefit special-status species including Federally listed fish, and several other plant and wildlife species. A primary component is to create juvenile salmonid habitat by constructing a vegetated bench with a range of elevations that will be inundated by typical winter and spring river stages. The range of elevations is designed to provide shallow (*i.e.*, 1 to 3 feet) of inundation in the target seasons and to create several planting zones related to hydrologic characteristics. The planting zones will provide a mixture of vegetation types to protect against erosion and provide cover for salmonids. The grading and planting plan is also designed to minimize predator species habitat and eliminate potential fish stranding in an existing closed depression in the terrace at the site. The project design is intended to be consistent with management objectives for Discovery Park, including those presented in the River Corridor Management Plan for the Lower American River.

In November 2006, The Corps SRBPP and CDWR's Division of Engineering constructed 33 critical levee erosion repair projects in the Sacramento River, the Bear River, and in Sutter and Cache Sloughs. The Corp's SRBPP constructed bank protection repairs at thirteen sites, along the Sacramento River between RMs 26.9 and 123.5. CDWR constructed bank protection repairs at sixteen sites in the SRFCP. Ten sites were along the Sacramento River, two sites were along the Bear River, two sites were along Cache Slough, one sight was along Sutter Slough, and one site was along Butte Creek. A setback levee was constructed at RM 145.9 to avoid adverse impacts to sensitive aquatic resources. These projects placed rock and wood revetments along the waterside slope of each erosion site. One repair along the Sacramento River was a set-back levee. Overall, these projects reinforced approximately 25,801 lf of shoreline, covering approximately 50.9 acres, with 26.4 acres of rock riprap placed below the MSW. The area above the MSW was covered with soil and planted with riparian vegetation at all Corps and some CDWR sites. Seasonally inundated benches total approximately 11.6 acres. Approximately 6,795 lf of IWM was placed both above the MSW and 7,346 lf was placed below the MSW.

Similar to the proposed action, the previous 33 bank protection projects were designed to repair bank and levee erosion and restore and enhance the riparian and SRA habitat. Generally, this was accomplished by incorporating rock benches, that serve as buffers against extreme toe scour and shear stress while providing space for planting riparian vegetation and creating a platform to support aquatic habitat features. This approach recreates the elements of natural SRA habitat that otherwise would be lost as a result of project construction activities and continued erosion. Implementation of these conservation measures was meant ensure that long-term impacts associated with existing, and future bank protection projects are compensated in a way that prevents incremental habitat fragmentation and reductions of the conservation value of aquatic habitat to anadromous fish within the action area. Successful implementation of all conservation measures is expected to improve migration and rearing conditions for juvenile anadromous fish by increasing the amount of flooded shallow water habitat and SRA habitat throughout the action area.

Despite the integrated conservation measures, long- and short-term impacts are expected. Primarily, long-term (*i.e.*, 5 to 50 year) impacts to listed salmonids will occur in the form of injury or death to juveniles summer and fall water surface elevations from the modification of shoreline habitat and the loss of IWM and other SRA. Short-term (*i.e.*, 1 to 5 year) effects will occur at winter and spring water surface elevations, primarily from the temporary reduction of IWM and riparian vegetation. Overall, substantial long-term improvements are expected for the life of the project due to the construction of benches, the application of soil and IWM, and the extensive planting of riparian vegetation.

Preliminary reviews of the 33 sites indicate that construction at CDWR sites removed substantially more riparian vegetation, and placed less IWM than was initially anticipated by NMFS. Additionally, much of the soil placement and revegetation plans were postponed until the spring of 2007 due to construction delays and a shortage of a suitable stock of plants. However, CDWR intends to place soil and plant riparian vegetation as soon as possible once site conditions allow. Additionally, as a condition of the June 21, 2006, biological opinion, amended on October 18, 2006, CDWR must coordinate with the Corps to develop a habitat and species compensation strategy and implement any actions necessary to fully compensate for unavoidable impacts within 12 months. CDWR also will conduct a follow-up SAM analysis and will conduct several years of SAM-related monitoring. If the habitat values do not meet the modeled values, additional compensation measures will be implemented. Because of this, NMFS expects that the compensation requirements will be followed and that the project impacts and improvements ultimately will meet NMFS expectations.

In January, 2007, the Corps began construction on an additional 14 sites, totaling approximately 9,817 lf along the Sacramento River and Sutter Slough. Similar to the 33 projects constructed in 2006, these projects are placing rock and wood revetments along the waterside slope of each erosion site. Once complete, these projects will affect approximately 21.7 acres, vegetated approximately 13.3 acres, and placed approximately 7,705 lf of IWM.

Comprehensive aquatic evaluations of the project are not available. Previous biological opinions written since 2001 have emphasized the need for a comprehensive monitoring and evaluation program. In response to these biological opinions, the Corps and CDWR have convened an aquatic monitoring committee that included biologists and engineers from the Corps, CDWR, USFWS, CDFG, and NMFS. The Corps has awarded contracts to begin preliminary aquatic and physical habitat monitoring at all of the sites they have constructed since 2001.

2. <u>Southern Distinct Population Segment of North American Green Sturgeon</u>

Point source and non-point pollution resulting from agricultural discharge and urban and industrial development occurs in the action area. The effects of these impacts are discussed in detail in the *Status of the Species and Habitat* section. Environmental stresses as a result of low water quality can lower reproductive success and may account for low productivity rates of green sturgeon (Klimley 2002). Organic contaminants from agricultural drain water, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of fish in the Sacramento River (USFWS 1995). Principle sources of organic contamination in the Sacramento River are rice field discharges from Butte Slough, Reclamation District 108, Colusa Basin Drain, Sacramento Slough, and Jack Slough (USFWS 1995). In addition, organic contaminants from agricultural returns, urban and agricultural runoff from storm events, and high trace element concentrations may deleteriously affect early life-stage survival of green sturgeon. The high number of diversions in the action area on the Sacramento River and in the north Delta are a potential threat to North American green sturgeon. Other impacts to adult migration present in the action area, such as migration barriers, water conveyance factors, and water quality, non-native fish species, *etc*., are discussed in the *Status of Species and Critical Habitat* section.

The Sacramento River is utilized by larvae and post-larvae and to a lesser extent, juvenile North American green sturgeon for rearing and migration purposes. Although it is believed that larvae and post-larvae as well as juveniles primarily are benthic (with the exception of the post-larvae nocturnal swim-up believed to be a dispersal mechanism), the massive channelization effort in the action area has resulted in a loss of ecosystem properties (USFWS 2000, Sweeney *et al*. 2004). Channelization results in reduced food supply (aquatic invertebrates), and reduced pollutant processing, organic matter processing, and nitrogen uptake (Sweeney *et al*. 2004).

C. Likelihood of Species Survival and Recovery in the Action Area

A majority of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead currently utilize the Sacramento River Delta for rearing and migration. Some of these fish are expected to use off-channel estuarine sloughs for rearing and migration. Although the fish habitat in these areas is currently degraded, it has a high conservation value for the species because of its location, and the features it provides that are essential to fulfilling certain life history requirements such as growth during outmigration. Recent improvement in bank protection practices that integrate fish habitat features will contribute to improvements of habitat condition and function throughout the action area.

In their recent evaluation of the viability of Central Valley salmonids, Lindley *et al*. (2006a) found that extant populations of Sacramento River spring-run and winter-run Chinook salmon appear to be at low risk of extinction. These populations meet the several viability criteria including population size, growth, and risk from hatchery strays. The viability of the ESU to which these populations belong appears low to moderate, but remain vulnerable to extirpation due to their small-scale distribution and high likelihood of being affected by a significant catastrophic event. Lindley *et al*. were not able to determine the viability of existing steelhead populations, but believe that the DPS has a moderate to high risk of extirpation since most of the historic habitat is inaccessible due to dams, and because the anadromous life-history strategy is being replaced by residency.

The Southern DPS of North American green sturgeon utilize the mainstem Sacramento River for spawning, rearing, and migration purposes. In addition, the Southern DPS of North American green sturgeon are known to occur in Delta areas, and recently have been seen in the Feather and Yuba River. Habitats of the Sacramento River are very important for the Southern DPS of North American green sturgeon as they are the only know location of spawning. Recent population estimates indicate that there are few fish relative to historic conditions, and that loss of habitat has affected population size and distribution. However, sturgeon remain widely distributed along the Pacific coast from California to Washington, and recent findings of fish in the Feather and the Yuba River indicate that their distribution in the Central Valley may be more broad that the previously thought. This suggests that the DPS probably meets several viable species population (VSP) criteria for distribution and diversity, and indicates that the Southern DPS of North American green sturgeon faces a low to moderate risk of extirpation.

Based on these viability assessments, and the recent habitat improvements that occurring throughout the action area to improve the conservation value of aquatic habitat for listed fish, Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the southern DPS of North American green sturgeon are likely to continue to survive and recover in the action area.

V. EFFECTS OF THE ACTION

A. Approach to the Assessment

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This biological opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat. NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species. This biological opinion assesses the effects of the proposed action on endangered Sacramento River winter-run Chinook salmon, threatened CV spring-run Chinook salmon, threatened CV steelhead, their designated critical habitat, and threatened Southern DPS of North American green sturgeon.

In the *Description of the Proposed Action* section of this biological opinion, NMFS provided an overview of the action. In the *Status of the Species* and *Environmental Baseline* sections of this biological opinion, NMFS provided an overview of the threatened and endangered species and critical habitat that are likely to be adversely affected by the activity under consultation.

Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). Section 7 of the ESA and its implementing regulations also require biological opinions to determine if Federal actions would destroy or adversely modify the conservation value of critical habitat (16 U.S.C. §1536).

NMFS generally approaches "jeopardy" analyses in a series of steps. First, we evaluate the available evidence to identify the direct and indirect physical, chemical, and biotic effects of proposed actions on individual members of listed species or aspects of the species' environment (these effects include direct, physical harm or injury to individual members of a species; modifications to something in the species' environment - such as reducing a species' prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors or a sound. Once we have identified the effects of an action, we evaluate the available evidence to identify a species' probable response (including behavioral responses) to those effects to determine if those effects could reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; among others). We then use the evidence available to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

To evaluate the effects of the proposed action, NMFS examined proposed construction activities, O&M activities, habitat modification, and conservation measures, to identify likely impacts to listed anadromous salmonids within the action area based on the best available information.

The information used in this assessment includes fishery information previously described in the *Status of the Species* and *Environmental Baseline* sections of this biological opinion; studies and accounts of the impacts of riprapping and in-river construction activities on anadromous habitat and ecosystem function; and documents prepared in support of the proposed action, including the BA; SAM results; project designs; field reviews; and meetings held between NMFS and the BALMD.

B. Assessment

The assessment will consider the nature, duration, and extent of the proposed action relative to the migration timing, behavior, and habitat requirements of Federally listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon. Specifically, this assessment will consider the potential impacts related to construction and O&M activities, and will use the SAM model (Corps 2004) to assess species response to habitat modifications from proposed bank protection projects over a 50-year period. At this time, the SAM does not apply to green sturgeon. Therefore, long-term impacts to green sturgeon will be evaluated separately from impacts to anadromous salmonids.

The assessment of effects considers the potential occurrence of Federally listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon, relative to the magnitude, timing, frequency, and duration of project activities. Effects of the proposed project on aquatic resources include both short- and long-term impacts. Short-term effects, which are related primarily to construction activities (*i.e.*, increased suspended sediment and turbidity), could last several hours to several weeks. O&M impacts are related to annual actions necessary to maintain project features and may occur for the life of the project (*i.e.*, 50 years). Long-term impacts may last months or years and generally involve physical alteration of the river bank and riparian vegetation adjacent to the water's edge.

The project sites are downstream from the spawning habitat of Chinook salmon, steelhead, and the Southern DPS of North American green sturgeon. Therefore, no short- or long-term effects on spawning habitat are expected.

1. <u>Short-term Construction-related Impacts</u>

In-water construction activities, including the placement of rock revetment, could result in direct effects to fish from the placement of rock into occupied habitat during peak migration periods. The project would result in localized, temporary disturbance of habitat conditions that may alter natural behavior patterns of adult and juvenile fish and cause the injury or death of individuals. These effects may include displacement, or impairment of feeding, migration, or other essential behaviors by adult and juvenile salmon, steelhead, and green sturgeon from noise, suspended sediment, turbidity, and sediment deposition generated during in-water construction activities. Some of these effects could occur in areas downstream of the project sites, because noise and sediment may be propagated downstream.

Construction will occur from February 2007 through mid-May 2007, and will affect approximately 3,500 lf of river and slough bank and channel bottom. The extent of construction-related effects is dependant upon the timing of fish presence in the action area, and their ability to successfully avoid project-related disturbance. Peak winter-run Chinook salmon emigration in the action area occurs between November and January, and commonly coincides with initial flow increases of up to 20,000 cfs, which occur from December through February. Juvenile CV spring-run Chinook salmon and CV steelhead migration can begin as early as November, but similar to winter-run, the peak migration occurs during sustained high flow periods between December and March. Sacramento River winter-run Chinook salmon are expected to be present in the action area from December through May. CV spring-run Chinook salmon are expected in the action area from January through July, and CV steelhead will be present from November through May.

Green sturgeon larvae and post-larvae are present in the action area between June and October with highest abundance during June and July (CDFG 2002), and remain in freshwater portions of the Delta for up to 10 months (Kynard *et al.* 2005). In addition, small numbers of juvenile sturgeon less than two years of age have been captured in the action area sporadically in the past (Jeff McLain, NMFS, pers. comm., 2006). Adult green sturgeon holding occurs in the Sacramento River in deep pools for up to six months per year, primarily between March and July (USFWS 2002).

a. *Potential Direct Effects from Rock Placement into Occupied Aquatic Habitat*

(1) *Salmon and Steelhead*

The placement of rock below the waterline will cause noise and physical disturbance that could displace juvenile and adult fish into adjacent habitats, or crush and injure or kill individuals. The impact of rock being placed in the river disrupts the river flow by producing surface water waves disturbing the water column; resulting in increased turbulence and turbidity. Migrating juveniles react to this situation by suddenly dispersing in random directions. This displacement can lead them into predator habitat where they can be targeted, and injured and killed by opportunistic predators taking advantage of juvenile behavioural changes. Carlson *et al*. (2001) observed this behaviour occurring in response to routine channel maintenance activities in the Columbia River. Some of the fish that did not immediately recover from the disorientation of turbidity and noise from channel dredges and pile driving swam directly into the point of contact with predators. Feist *et al*. (1992) found that noise from pile driving activities in the Puget Sound affected the general behaviour of juveniles by temporarily displacing them from construction areas. Nearly twice as many fish were observed at construction sites on non-pile driving days compared to days when pile driving occurred.

Biological studies conducted at GCID also support that predation may be higher in areas where juveniles are disoriented by turbulent flows or are involuntarily routed into high-quality predator habitat or past areas with higher predator densities (Vogel 2004). Behavioural observations of predator and salmon interactions at GCID also surmised that predators responded quickly to the release of fish during the biological tests and preyed on fish soon after they were released into the water, even when the release locations were periodically changed (David Vogel, Natural Resource Scientists, pers. comm. 2006). This is a strong indication that predators quickly respond to changes in natural juvenile salmonid behavioural responses to disturbance.

NMFS was unable to find any scientific evidence that fish may be injured or killed by crushing from rock placement. Regardless, many juvenile fish are small, relatively slow swimmers, typically found in the upper two feet of the water column, and oriented to nearshore habitat. Larger fish, including adults and smolts probably would respond by quickly swimming away from the placement site, and would escape injury or death. Fry-sized fish (those that are less than 50 mm) that are directly in the path of rock placement may be less likely to avoid the impact. Therefore, it appears likely that the placement of large quantities into this habitat has the potential to crush and injure or kill fry-sized salmon and steelhead. However, the best available outmigration data throughout the Sacramento River, indicate that fry-size listed salmon or steelhead are unlikely to be present in the action area during the construction period, unless flood conditions wash fish downstream. In such a case, the BALMD would suspend construction until flows subsided. Therefore, it appears to be unlikely that salmon and steelhead will be injured or killed from being crushed by rock.

The operation of heavy equipment such as crane-mounted barges and the sound generated by construction activities may temporarily affect the behavior of migrating adult salmonids, possibly causing migration delays. However, construction activities are not likely to injure or kill adult winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead because of their crepuscular migration behavior, and because these fish tend to utilize mid-channel, deep water habitats. Construction will be restricted to the channel edge, and would include implementation of the avoidance and minimization measures that will prevent impacts to these migration corridors.

(2) ***Green Sturgeon***

Rock placement will occur while green sturgeon are present in the action area. In-water activities could cause injury or mortality to individual green sturgeon that do not readily move away from the areas directly affected by rock placement. However, NMFS expects that since juvenile and adult green sturgeon show a preference for benthic habitat types, few fish should be exposed to rock placement along the shoreline, and construction activities are not likely to injure or kill juveniles or adults.

b. *Potential Effects of Sediment and Turbidity*

Rock placement and nearshore construction will disturb soils and the riverbed and result in increased erosion, siltation, and sedimentation. Short-term increases in turbidity and suspended sediment may disrupt feeding activities of fish or result in temporary displacement from preferred habitats.

(1) *Salmon and Steelhead*

Numerous studies show that suspended sediment and turbidity levels moderately elevated above natural background values can result in non-lethal detrimental effects to salmonids. Suspended sediment affects salmonids by decreasing reproductive success, reducing feeding success and growth, causing avoidance of rearing habitats, and disrupting migration cues (Bash *et al.* 2001). Sigler *et al.* (1984) in Bjornn and Reiser (1991) found that prolonged turbidity between 25 and 50 Nephelometric Turbidity Unit (NTUs) reduced growth of juvenile coho salmon and steelhead. Macdonald *et al.* (1991) found that the ability of salmon to find and capture food is impaired at turbidities from 25 to 70 NTUs. Bisson and Bilby (1982) reported that juvenile coho salmon avoid turbidities exceeding 70 NTUs. Increased sediment delivery can also fill interstitial substrate spaces and reduce cover for juvenile fish (Platts *et. al.* 1979) and abundance and availability of aquatic invertebrates for food (Bjornn and Reiser 1991). We expect turbidity to affect Chinook salmon and steelhead in much the same way that it affects other salmonids, because of similar physiological and life history requirements between species.

Newcombe and Jensen (1996) believe that impacts on fish populations exposed to episodes of high suspended sediment may vary depending on the circumstance of the event. They also believe that wild fish may be less susceptible to direct and indirect effects of localized suspended sediment and turbidity increases because they are free to move elsewhere in the system and avoid sediment related effects. They emphasize that the severity of effects on salmonids depends not only on sediment concentration, but also on duration of exposure and the sensitivity of the affected life stage.

Suspended sediment from construction activities would increase turbidity at the project site and could continue downstream. Although Chinook salmon, steelhead, are highly migratory and capable of moving freely throughout the action area, an increase in turbidity may injure fish by temporarily disrupting normal behaviors that are essential to growth and survival such as feeding, sheltering, and migrating. Injury is caused when disrupting these behaviors increases the likelihood that individual fish will face increased competition for food and space, and experience reduced growth rates or possibly weight loss. Project-related turbidity increases may also affect the sheltering abilities of some fish and may decrease their likelihood of survival by increasing their susceptibility to predation.

Construction activities are expected to result in periodic turbidity levels that exceed 25 to 75 NTUs, and thus capable of affecting normal feeding and sheltering behavior. Based on observations during similar construction activities in the Sacramento River, turbidity plumes are not expected to extend across the Sacramento River, but rather the plume is expected to extend downstream from the site along the side of the channel. Turbidity plumes will occur during in-water construction. At a maximum, these plumes are expected to be as wide as 100 feet, and extend downstream for up to 1,000 feet. Most plumes extend into the channel approximately 10 to 15 feet, and downstream less than 200 feet. Once construction stops, water quality is expected to return to background levels within hours. Adherence to erosion control measures and BMPs such as use of silt fences, straw bales and straw wattles will minimize the amount of project-related sediment and minimize the potential for post-construction turbidity changes. Since project-related turbidity plumes will be limited to shoreline construction areas, NMFS expects that individual fish will mostly avoid the turbid areas of the river. For those fish that do not avoid the turbid water, exposure is expected to be brief (*i.e.*, minutes to hours) and not likely to cause injury or death from reduced growth, or physiological stress. This expectation is based on the general avoidance behaviors of salmon and the BALMD proposal to suspend construction when turbidity exceeds Regional Board standards. Once fish migrate past the turbid water, normal feeding and migration behaviors are expected to resume. However, those juveniles that are exposed to project construction are expected to encounter short-term (*i.e.*, minutes to hours) construction-related water quality changes that will cause injury or death to some individuals by temporarily disrupting normal behaviors, affecting juvenile sheltering abilities, and increasing their susceptibility to predation.

(2) *Green Sturgeon*

Green sturgeon will be present in the action area during construction, and therefore may be exposed and affected by short-term increases in turbidity and suspended sediment if these increases disrupt feeding and migratory behavior activities of post-larvae, juvenile, and adult fish. Turbidity and sedimentation events are not expected to affect visual feeding success of green sturgeon, as they are not believed to utilize visual cues (Sillman *et al.* 2005). Instead, olfaction appears to be a key feeding mechanism. In addition, green sturgeon are primarily benthic, and their presence along the shoreline is not expected to be common. Therefore, adverse effects including injury or death from temporary increases in sediment and turbidity are not likely.

c. *Other Potential Water Quality Effects*

Toxic substances used at construction sites, including gasoline, lubricants, and other petroleum-based products could enter the Sacramento River as a result of spills or leakage from machinery or storage containers and injure or kill listed salmon, steelhead, and green sturgeon. These substances can kill aquatic organisms through exposure to lethal concentrations or exposure to non-lethal levels that cause physiological stress and increased susceptibility to other sources of mortality. Petroleum products also tend to form oily films on the water surface that can reduce DO levels available to aquatic organisms. NMFS expects that adherence to BMPs that dictate the use, containment, and cleanup of contaminants will minimize the risk of introducing such products to the waterway because the prevention and contingency measures will require frequent equipment checks to prevent leaks, will keep stockpiled materials away from the water, and will require that absorbent booms are kept on-site to prevent petroleum products from entering the river in the event of a spill or leak. NMFS does not expect the project to result in water contamination that will injure or kill individual fish.

d. *Summary of Construction-related Effects*

(1) *Salmon and Steelhead*

NMFS expects that a large, but unknown, number of anadromous salmonids will be present in the action area during construction because of the peak migration periods that occur during this time. Those fish that are exposed to project construction will encounter short-term (*i.e.*, minutes to hours) construction-related noise, physical disturbance, and water quality changes that may cause injury or death by increasing the susceptibility of some individuals to predation by temporarily disrupting normal behaviors and affecting sheltering abilities. Some juvenile fish may be crushed, and killed or injured during rock placement. Others may be displaced from natural shelter and preyed upon by piscivorous fish. Although construction will occur during peak migration periods, relatively few juvenile fish are expected to be injured or killed by in-river construction activities because most fish are expected to avoid construction activities due to their predominately crepuscular migration behaviors. The implementation of BMPs and other on-site measures also will minimize impacts to the aquatic environment and reduce project-related effects to fish. In addition, peak migration events correspond with periods of high river flows, when in-river construction activities are likely to be suspended. Furthermore, only one cohort, or emigrating year class, out of perhaps four to five within each salmon and steelhead population will be affected. Therefore, NMFS expects that actual injury and mortality levels will be low relative to the overall population abundance, and not likely to result in any long-term, negative population trends. Adults should not be injured because their size, preference for deep water, and their crepuscular migratory behavior will enable them to avoid most temporary, nearshore disturbance.

(2) *Green Sturgeon*

NMFS expects that a large, but unknown, number of green sturgeon will be present in the action area during construction because of the peak migration periods that occur during this time. Green sturgeon are primarily benthic, and their presence along the shoreline is not expected to be common. Therefore, adverse effects including injury or death from construction activities are not likely.

e. *Construction-related effects to Critical Habitat*

Construction activities will alter the site-scale physical characteristics of the PCEs of salmon and steelhead critical habitat, including elements of freshwater and estuarine rearing and migration habitat. These effects are discussed in detail below in *Section 3, Long Term Impacts as Projected by the SAM Model*. Impacts that occur during construction are quantified in the SAM analysis as effects that occur in year 1.

2. Effects of Project Operation and Maintenance

Anticipated O&M actions include vegetation management and irrigation for up to three years and periodic rock placement to prevent or repair localized scouring. Effects would be limited to the annual placement of small quantities of material to patch sections of repaired levees that have undergone further erosion. Impacts from O&M actions will be similar to the impacts of initial construction, and include injury or death to salmon and steelhead from predation cause by turbidity changes that temporarily disrupt normal behaviors, and affect sheltering abilities. However, since O&M actions are only expected to repair damaged elements of the project, they are expected to be infrequent (*i.e.*, occurring only once every several years), small (*i.e.*, only affecting small sections of the project area), and will not occur at all sites. Therefore relatively few fish should be affected by O&M actions, and actual injury and mortality levels will be low relative to overall population abundance and not likely to cause any long-term, negative population responses. O&M actions that affect habitat conditions will include BMPs, summer in-water construction windows, and other minimization and avoidance measures will be implemented to reduce these effects to anadromous salmonids, green sturgeon, and their habitat.

3. Long-Term Impacts as Projected by the SAM Model

The project is expected to result in long-term habitat modifications, including modifications to the designated critical habitat of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead. The modifications will affect fish behavior, growth and survival, and the PCEs of critical habitat including freshwater and estuarine rearing sites and migration corridors.

Long-term project effects include the alteration of river hydraulics and cover along approximately 3,500 lf of shoreline as a result of changes in bank configuration and structural features. These changes may affect the quantity and quality of nearshore habitat for juvenile Chinook salmon, steelhead. Slopes protected with rock revetment generally create nearshore hydraulic conditions characterized by greater depths and faster, more homogeneous water velocities than occur along natural banks. Higher water velocities typically inhibit the deposition and retention of sediment and woody debris. These changes generally reduce the range of habitat conditions typically found along natural shorelines, especially by eliminating the shallow, slow-velocity river margins used by juvenile fish as refuge and escape from fast currents, deep water, and predators.

Removal of riparian vegetation and IWM from stream banks results in the temporal loss of a primary source of overhead and instream cover for juvenile salmonids. The removal of riparian vegetation and IWM and the replacement of natural bank substrates with rock revetment can adversely affect important ecosystem functions. Living space and food for terrestrial and aquatic invertebrates is lost, eliminating an important food source for juvenile salmonids. Loss of riparian vegetation and soft substrates reduces inputs of organic material to the stream ecosystem in the form of leaves, detritus, and woody debris, which can affect biological production at all trophic levels. The magnitude of these effects depends on the degree to which riparian vegetation and natural substrates are preserved or recovered during the life of the project. As a result, habitat diversity, complexity, and quality for survival and growth are diminished.

Several project features were designed to address the need for ecologically functional shallow-water, floodplain habitat, riparian habitat, and cover in the confined reaches of the lower Sacramento River. The inclusion of a low bench, plantings of emergent wetland and riparian vegetation will help restore habitat diversity. Irregular shorelines, riparian vegetation, and variability in bench elevations are expected to create low-velocity zones of deposition where sediment and organic material will be stored and made available to aquatic invertebrates and other decomposers. Vegetated low benches also will provide high-quality shallow water habitat for fish during winter and spring that will increase in value over time, as the vegetation becomes established.

Riparian vegetation along streams provides shade, which incrementally moderates stream temperatures and prevents direct solar exposure of fish at shallow depths. The role of riparian shade in moderating stream temperatures is greatest on small streams and decreases with increasing stream size. Because of the large size of the Sacramento River, relative to its existing shoreline canopy, the effect of riparian vegetation in moderating water temperatures is minor, compared with the effects of reservoir operations, discharge, and meteorological conditions.

a. *SAM Analysis*

The SAM was used to quantify the responses of listed fish species to with-project conditions over a 50-year project period and compared to the species responses under without-project (existing) conditions. The assessment followed the general steps outlined in the *SAM Final Review Draft and Users Manual* (Stillwater Sciences and Dean Ryan Consultants & Designers 2004, 2006). Computations were performed using the Electronic Calculation Template provided by Stillwater Sciences.

The SAM was designed to address a number of limitations associated with previous habitat assessment approaches and provide a tool to systematically evaluate the impacts and compensation requirements of bank protection projects based on the needs of listed fish species. A major advantage of the SAM is that it integrates species life history and flow-related variability in habitat quality and availability to generate species responses to project actions over time. Species responses represent an index of a species growth and survival based on a 30-day exposure to post project conditions at a variety of seasons and life-history stages, over the life of the project. Negative responses (SAM deficits), are indicators of reduced growth and survival conditions relative to baseline conditions, and positive responses, are indications of improved growth and survival conditions.

The model is capable of projecting how without-project conditions would change over time. However, the modeling for these projects compared the with-project conditions to a static existing baseline because it simplifies the interpretation of modeling results and because, based on site evaluations conducted by NMFS, the baseline conditions probably would decline due to the limited amount of remaining high quality habitat. Also, given the critical state of the existing sites, the without-project scenario is likely to include emergency flood fighting that would result in substantial habitat degradation.

The results of the SAM analysis are presented in Tetra Tech, 2006. The SAM quantifies habitat values in terms of bank line- or area-weighted species responses that are calculated by combining habitat quality (fish response indices) with quantity (bank length or wetted area) for each season, target year, and relevant species and life stage. The SAM (Stillwater Sciences, 2004) employs six habitat variables to characterize nearshore and floodplain habitats of listed fish species.

- Bank slope – This is the average bank slope along each average seasonal water surface elevation. Bank slope is an indicator of shallow-water habitat availability, which is important for juveniles for feeding, rearing, and refugia from high flows and predators. The relationship of bank slope to fish response is related to how variations in fish size and foraging strategies affect growth potential and expose various species and life stages to predation risk. For fry and smolts of each species, shallow water near the bank is considered to be high value because it provides refuge from predators and low velocity feeding and rearing habitat (Power 1987, Schlosser 1991, and Waite and Barnhart 1992). Smaller fish can avoid predation by piscivorous fish to some degree by selecting shallower water. Although larger fish (*i.e.*, smolts) typically use deeper water habitats, it is assumed that predation risk also increases. Adult life stages are not affected by the same predation as juveniles and tend to utilize deep, mid-channel habitat as migratory corridors. Therefore, adults are not expected to be sensitive to changes in bank slope.

  Based on a compilation of the last ten years of hourly water surface elevation (WSEL), data collected by the CDWR from the Rio Vista Bridge (October 1995 to October 2006), the WSELs for the region of the Brannan-Andrus levee repair sites is nearly completely dominated by daily tidal action and is minimally influenced by periods of seasonal flow (Tetra Tech 2006).

- Floodplain availability – This is the ratio of wetted channel and floodplain area during the 2-year flood to the wetted channel area during average winter and spring flows. Floodplain availability is used as an indicator of seasonally flooded shallow-water habitat availability, which is important for juveniles for feeding, rearing, and refugia from high flows and predators. Use of seasonally inundated flooded habitat is generally considered to increase growth of juvenile salmonids due to greater access to areas with high invertebrate productivity from flooded terrestrial matter (Sommer *et al.* 2001). Predation risk in seasonally flooded areas is expected to be less in seasonally inundated areas with large amounts of hiding cover and a lack of piscivorous fish. Adult life stages tend to utilize deep, mid-channel habitat and are not expected to be sensitive to changes in floodplain availability.

Floodplain variability was estimated from aerial photographs and engineering cross-sections of the project sites. Based on these analyses, there are no significant changes in the wetted width of the river expected under the with-project conditions.

- Bank substrate size – This is measured as the median particle diameter of the bank (*i.e.*, D50) immediately below (*i.e.*, 0 to 3 feet) each average seasonal water surface elevation. Bank substrate size is used as an indicator of juvenile refugia from predators, but also as an indicator of suitable predator habitat. Increased predator density has been observed at riprapped sites relative to natural banks at studies in the Sacramento River and the Delta (Michny and Deibel 1986, Michny 1989). Substrate size also is used as an indicator of food availability. The effects of substrate size on mortality risk are expected to be greatest at small grain sizes due to a lack of cover from avian and piscivorous fish predation. Predation risk is lower at intermediate sizes close to the size of the affected life stage because small interstitial spaces offer cover from predators. Predation risk is highest when grain sizes exceed the length of the affected life stage, because interstitial spaces are capable of providing effective cover for piscivorous fish species. Adult life stages tend to utilize deep, mid-channel habitat and are not expected to be sensitive to changes in bank substrate size.

- Instream structure – This is measured as the percent of shoreline coverage of IWM along each average seasonal water surface elevation. The value of instream structure to salmonids has been directly demonstrated by various studies. Instream structure is an indicator of juvenile refugia from predators (Michny and Hampton 1984, Michny and Deitel 1986). Instream structure is used as an indicator of food availability, feeding station availability, and as cover and resting habitat for adults. Instream structure provides high quality resting areas for adults and juveniles, cover from predation, and substrate for macroinvertebrate production (USFWS 2000, Lassettre and Harris 2001, Piegay 2002).

- Aquatic and submerged terrestrial vegetation – This is measured as the percent of shoreline coverage of aquatic or riparian vegetation along each average seasonal water surface elevation. Aquatic vegetation is used as an indicator of juvenile refugia from predators, and food availability. Rearing success is strongly affected by aquatic vegetation (Corps 2004). Biological response to aquatic vegetation is influenced by the potential for food production and cover to sensitive life stages. Because salmonid fry and juveniles are commonly found along shore in flooded vegetation (Cannon and Kennedy 2003) increases in aquatic and submerged terrestrial vegetation is expected to result in a positive salmonid response (*i.e.*, increased growth, reduced risk of predation). Adult salmonids are not expected to be sensitive to changes in aquatic or submerged terrestrial vegetation.

- Overhanging shade – This is measured as the percent of the shoreline coverage of shade along each average seasonal water surface elevation. The value of overhanging shade is an indicator of juvenile refugia from predators, and food availability. Numerous studies have shown the importance of overhanging shade to salmonids. Shade provides overhead cover and allochthonous input of leaf litter and insects which provide food for juveniles. Michny and Hampton (1984), and Michny and Deibel (1986) juvenile salmonid abundance was highest in reaches of the Sacramento River with shaded riparian cover.

SAM model results for this project are summarized in Appendix A and B of Tetra Tech (2006). As with many models, SAM modeling is based on many assumptions about species behavior and response to habitat changes. There also are untested assumptions regarding the response of physical project elements to river flows and other unpredictable environmental events. Therefore, there is a considerable amount of uncertainty regarding the results. To account for some of the uncertainty, the Corps, NMFS, USFWS, and scientists from Stillwater Sciences discussed and agreed upon conservative model input variables that tend to generate worst-case scenarios based on conservative estimates of habitat modification and improvement overtime. The model itself accounts for some of the uncertainty by generating results at four different average water surface elevations. To account for site diversity, model input values are not measured only at discrete average flow elevations, but within three feet of these elevations. Although the model focuses on a discrete average water surface elevation, seasonal variability of average flows is accounted for in the project designs because project features, and conservation measures (*i.e.*, benches, vegetation) are placed at variable elevations. Long-term comprehensive monitoring will measure the success of model results by evaluating habitat evolution and fish habitat use. The design of monitoring studies, including frequency, duration, and location, is currently under development.

Further support for expectations regarding the physical response to habitat conditions over time is supplied by the monitoring results for similar projects in the American and Sacramento Rivers. Riparian and SRA monitoring at eight bank protection or revegetation projects along the American River, demonstrated that riparian goals for tree and shrub width, height, cover, and shoreline cover were met or exceeded at all sites (Ross 2006).

a. *Long-term Effects of PL 84-99 Actions on Anadromous Salmonids*

The SAM results indicate that for Chinook salmon the project would result in short term (*i.e.*, 5 to 15 years) deficits, and long-term (*i.e.*, 15 to 50 year) gains in the summer, fall, and spring habitat values for juvenile rearing and smolt life stages. The project will result in small decreases in winter habitat values for the same life stages for 15 to 50 years (Appendix B of Tetra Tech 2006). Long-term increases in Chinook salmon response indices reflect the positive responses of juveniles to increased availability of shallow water habitat, flooded vegetation, and IWM. However, the modeling used bank-line evaluations, which NMFS believes substantially undervalue the value of increased shallow water habitat that result from constructed bench designs during tidal inundation. Therefore, the modeled deficits are likely to overestimate the short-term effects to listed species. Actual short-term effects are therefore expected to last from 5 to 15 years, but deficits lasting 15 to 50 years are unlikely.

The short- and long-term responses of steelhead, both juvenile and smolts, to changes in the tidal (or seasonal) habitat conditions is similar to those described for the Chinook salmon for the same life stages (Table 1, Figure 3 of Tetra Tech 2006). The differences in magnitude of the response indices between the steelhead and Chinook salmon are indicative of the differences in the individual species response curves to individual habitat variables.

NMFS expects that his project will have little long-term effect on adult migration. Adult upstream-migrations occur mid-channel, and the changes to near-shore habitats resultiing from this project are not expected to change the hydrology of the mid-channel portion of the river.

b. *Long-term Effects of PL 84-99 Actions on the Southern DPS of North American Green Sturgeon*

Adult green sturgeon move upstream through the project sites between March and July. Long-term changes in nearshore habitat are expected to have negligible effects on adults because adult sturgeon use deep, mid-channel habitat during migration. The long-term effects of the proposed project related to North American green sturgeon adults would primarily be related to the alteration of the Sacramento River below the waterline as migrating and holding adults utilize benthic habitat. Therefore, NMFS expects that adult fish are not likely to be injured or killed as a result of the project since most fish are expected to migrate through deeper mid-channel pathways and will avoid direct exposure to project sites.

Although it is believed that larvae and post-larvae as well as juveniles primarily are benthic (with the exception of the post-larvae nocturnal swim-up believed to be a dispersal mechanism), the removal or reduction of riparian vegetation and IWM likely impacts potential prey items and species interactions that green sturgeon would experience while rearing and migrating. These changes are minimized considerably in the project design and the effects of this riparian and IWM removal or reduction would decrease through time as a result of the proposed projects conservation measures.

In the absence of modeled response data for green sturgeon, NMFS expects responses to long-term, project-related habitat conditions to be similar to juvenile salmonids. However, because green sturgeon are not as near-shore oriented as juvenile Chinook salmon, the relative proportion of the green sturgeon population that will be affected by these conditions should be low.

c. Long-term Effects of SRBPP Actions on Critical Habitat

The long-term effects of SRBPP actions on the critical habitat of winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead can be measured using the SAM results because they represent indices of fish response to habitat change. The condition of estuarine and freshwater rearing and migration PCEs will be affected by the project. PCEs will be reduced short-term (*i.e.*, 5 to 15 years), but show substantial long-term (*i.e.*, 5 to 50 year) increases above baseline conditions as the integrated habitat features such as shade, and aquatic vegetation become established and developed.

4. Impacts of Project Monitoring

The monitoring plan will involve photo documentation and point estimates of substrate size, riparian vegetation, and other physical project elements. Direct sampling of juvenile anadromous salmonids is not proposed. This monitoring is not expected to have any effect of Federally listed fish or designated critical habitat.

5. Impacts to Critical Habitat

Impacts to the designated critical habitat of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead include the short- and long-term modification of approximately 3,500 lf, of nearshore aquatic and riparian areas that are designated critical habitat. PCEs at the 13 sites include estuarine and riverine areas for rearing and migration.

The most substantial impacts to these PCEs result from loss of modification of riparian vegetation, IWM, shallow-water habitat, and the increase in bank substrate size. These losses and modifications affect the PCEs by reducing instream cover and food production, and increasing their susceptibility to predation, injury, and death. The condition of estuarine and freshwater rearing and migration PCEs will be affected by the project. PCEs will be reduced short-term (*i.e.*, 5 to 15 years), but show substantial long-term (*i.e.*, 5 to 50 year) increases above baseline conditions as the integrated habitat features such as shade, and aquatic vegetation become established and developed.

Despite the modeled habitat deficits, they are not expected to reduce the overall conservation value of rearing and migration PCEs because the majority of rearing and emigration within the action area does not occur during average fall flow conditions. Instead, a significant majority of Chinook salmon and steelhead rearing and emigration occurs during periods of higher flow that are more accurately represented by average winter and spring water surface elevations.

6. Interrelated or Interdependent Actions

Regulations that implement section 7(b)(2) of the ESA require biological opinions to evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536; 50 CFR 402.02). NMFS considered concurrent, ongoing repair of an additional 57 levee repair projects in the SRFCP as potentially interrelated or interdependent actions in the action. These projects are expected to result in effects to listed salmon, steelhead, and sturgeon that are similar to those previously described in this biological opinion for the proposed action, including short-term adverse effects to these species and their designated critical habitat. NMFS does not consider these actions to be interrelated because there is no single authority or program that binds them together, or interdependent because they would occur regardless of the proposed action.

VI. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Cumulative effects include non-Federal riprap projects. Depending on the scope of the action, some non-Federal riprap projects carried out by State or local agencies do not require Federal permits. These types of actions and illegal placement of non-Federal riprap are common throughout the action area. The effects of such actions result in continued fragmentation of existing high-quality habitat, and conversion of complex nearshore aquatic to simplified habitats that affect salmonids in ways similar to the adverse effects associated with the proposed action. Reasonably certain cumulative effects include any continuing or future non-Federal water diversions. Water diversions through intakes serving numerous small, private agricultural lands and duck clubs along the lower Sacramento River contribute to these cumulative effects. These diversions also include municipal and industrial uses as well as water for power plants. Water diversions affect salmonids and sturgeon by entraining, and injuring or killing adult or juvenile fish.

Additional cumulative effects may result from the discharge of point and non-point source chemical contaminant discharges. These contaminants include selenium and numerous pesticides and herbicides associated with discharges related to agricultural and urban activities. Contaminants may injure or kill salmonids by affecting food availability, growth rate, susceptibility to disease, or other physiological processes necessary for survival.

VII. INTEGRATION AND SYNTHESIS

A. Impacts of the Proposed Action on Sacramento River Winter-run Chinook Salmon, Central Valley Spring-run Chinook Salmon, Central Valley Steelhead

NMFS expects that the proposed action will result in adverse short-term, construction-related impacts, O&M-related impacts, habitat impacts that will capture, injure, and kill Federally listed Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead. Construction-related effects are expected to affect juveniles. Juveniles are expected to be affected because of their small size, reliance on nearshore aquatic habitat, and vulnerability to factors that injure or kill them, or otherwise affect their growth and survival, such as noise or crushing of fish from rock placement and barge activity, changes in water quality that temporarily modify their natural behavior and may reduce their growth or expose them to predation.

Construction impacts to juveniles, occurring for a distance of approximately 3,500 lf of aquatic habitat along the banks of the Sacramento River, are expected to impact juveniles from February 2007 through mid-May 2007. Although construction will occur during peak migration periods, relatively few juvenile fish are expected to be injured or killed by in-river construction activities because most fish are expected to avoid construction activities due to their predominately crepuscular migration behaviors, and most of those that are exposed to construction are expected to detect project-related disturbance and noise and avoid being injured or killed. The implementation of BMPs and other on-site measures also will minimize impacts to the aquatic environment and reduce project-related effects to fish. Furthermore, only one cohort, or emigrating year class, out of perhaps four to five within each population will be affected. Therefore, NMFS expects that actual injury and mortality levels will be low relative to the overall population abundance, and not likely to result in any long-term, negative population trends. Adults should not be injured because their size, preference for deep water, and crepuscular migratory behavior enable them to avoid temporary, nearshore disturbance.

O&M impacts will occur for the life of the project and primarily will be caused by infrequent in-water construction and rock placement necessary to maintain the project in functional condition. O&M activities are expected to occur between July 1 and November 30 for the life of the project (*i.e.*, 50 years). Individuals are expected to be injured or killed during the month of November from turbidity-induced predation during the annual placement of the bank protection material of no more than 600 cubic yards of material. Relatively few fish are expected to be injured or killed by O&M activities because the majority of construction will occur before high flows trigger peak migration, and because the implementation of BMPs and other on-site measures are expected to minimize impacts to the aquatic environment.

SAM-modeled habitat deficits may cause injury and death of individuals at all sites from reduced growth conditions and increased predation, for 1 to 15 years. Long-term effects as modeled by the SAM are expected to result in reduced growth and survival conditions for juvenile and smolt Chinook salmon and steelhead at all seasonal water surface elevations for 5 to 15 years and substantial gains in value from 15 to 50 years. Deficits at summer and fall flow conditions are greater that those at the winter and spring flows. The modeled summer and fall habitat deficits are expected to affect relatively few fish and will not be limiting to Chinook salmon or steelhead populations, since the majority of adult migration and juvenile rearing and emigration within the action area does not occur during average fall flow conditions. Instead, a significant majority of Chinook salmon and steelhead adult migration and juvenile rearing and emigration occurs during periods of higher flow that are more accurately represented by conditions at average winter and spring water surface elevations, where the habitat deficits are less, and the baseline conditions are reached or exceeded more quickly (*i.e.*, 5 to 10 years versus 10 to 15 years for fall and summer elevations). Additionally, since the project is located in the Delta, the majority of fish that will be exposed to the project area will be smolts. Smolts are actively migrating toward the ocean and spend less time seeking rearing and refuge areas than is the case farther upstream. Kjelson *et al*'s (1982) findings that tagged Chinook salmon fry can travel as fast as 30 km per day in the lower Sacramento River suggest that the SAM model's assumption of a 30-day exposure period to the project site is an over-estimate of effects. Other nearby habitats in the action area will continue to be available and offer cover and refugia to migrating fish. Long-term effects at the winter and spring water surface elevations will be substantially positive, with conditions improving beyond existing conditions through year 50.

B. Impacts of the Proposed Action on the Southern Distinct Population Segment of North American Green Sturgeon

NMFS also expects the action to adversely affect the Federally listed Southern DPS of the North American green sturgeon. Adverse effect to these species is expected to be limited to migrating and rearing larvae, post-larvae, juveniles and holding adults. Juveniles are expected to be affected most significantly because of their small size, reliance on aquatic food supply (allochthonous food production), and vulnerability to factors that affect their feeding success and survival. Construction activities will cause disruptions from increased noise, turbidity, and inwater disturbance that may injure or kill larvae, post-larvae, and juveniles by causing reduced growth and survival as well as increased susceptibility to predation. Adverse affects to adults are primarily limited to the alteration of habitat below the waterline affecting predator prey relationships and feeding success. As is the case for salmonids, the habitat and species-level impacts that are expected at certain sites will result in substantial long-term gains in nearshore and riparian health offering benefits to larvae, post-larvae, juvenile, and adult Southern DPS of North American green sturgeon.

C. Impacts of the Proposed Action on the Survival and Recovery of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead

The adverse effects to Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead within the action area are not expected to affect the likelihood of survival and recovery of the ESUs. This is largely due to the fact that the project will compensate for temporary and permanent habitat losses of habitat through implementation of on-site and off-site conservation measures. Most construction-related impacts will be temporary and will not impede adult fish from reaching upstream spawning and holding habitat, or juvenile fish from migrating to downstream rearing areas. The number of individuals actually injured or killed by construction and O&M activities is expected to be small because only fish that are present during the month of November are expected to be affected. Similarly, the number of fish that will be injured or killed as a result of short-and long-term habitat impacts, as indexed by the SAM will be low because the primary loss of habitat condition and function is limited to the low-flow fall water surface elevations, while the majority of juvenile fish are expected to be present during winter and spring months, when seasonal water elevations are higher, and integrated conservation measures such as riparian vegetation, overhanging shade, IWM and engineered benches are inundated and available to the species. Although Federally listed anadromous fish may be present in the action area during the fall months, abundance is relatively low compared to the number of fish that are present during winter months.

Similar to the previous 47 critical levee repair projects that have been constructed since July 2006, the integration and success of conservation measures, including re-establishing riparian vegetation, and constructing seasonally inundated shallow-water benches, will minimize the adverse effects on the PCEs of Sacramento River winter-run Chinook salmon, CV steelhead, and CV spring-run Chinook salmon habitat. Although the PCEs in the action area are currently degraded from conditions that support the conservation needs of the species, NMFS considers the value of this area for the conservation of the species to be high because its entire length is used for migration during extended periods of time by a large proportion of all Federally listed anadromous fish species in the Central Valley.

In addition to the factors affecting the species in the action area in the *Environmental Baseline* section of this biological opinion, which currently are addressing and reducing juvenile entrainment at water diversions, and habitat loss from levee maintenance, the proposed action has specifically been designed to minimize and avoid continued nearshore aquatic and riparian habitat loss from large-scale bank protection projects. The proposed implementation of the integrated conservation measures will ensure that short- and long-term impacts associated with these bank protection projects will be compensated in a way that prevents incremental habitat fragmentation, and loss area. Although some injury or death to individual fish is expected from construction activities, O&M, and short- and long-term habitat modification, successful implementation of all conservation measures is expected to improve migration and rearing conditions, and the growth and survival of juvenile salmon and steelhead during peak rearing and migration periods by protecting, restoring, and in many cases, increasing the amount of flooded shallow water habitat and SRA habitat throughout the action area. Because of this, the proposed action is not expected to reduce the likelihood of survival and recovery of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead within the action area.

D. Impacts of the Proposed Action on the Survival and Recovery of the Southern Distinct Population Segment of North American Green Sturgeon

The adverse effects to Southern DPS of North American green sturgeon within the action area are not expected to affect the overall survival and recovery of the DPS. This is largely due to the fact that the project will compensate for temporary and permanent habitat losses of habitat through implementation of on-site and off-site conservation measures. Construction-related impacts will be temporary and will not impede adult fish from reaching upstream spawning and holding habitat, or larvae, post-larvae, and juvenile fish from rearing or migrating to downstream rearing areas. The number of individuals actually injured or killed is expected to be undetectable and negligible and, population-level impacts are not anticipated. Implementation of the conservation measures will ensure that long-term impacts associated with bank protection projects will be compensated in a way that prevents incremental habitat fragmentation and reductions of the conservation value of aquatic habitat to anadromous fish within the action area. Because of this, the proposed action is not expected to reduce the likelihood of survival and recovery of the Southern DPS of North American green sturgeon within the action area.

E. Impacts of the Proposed Action on Critical Habitat

Impacts to the designated critical habitat of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead include the short- and long-term modification of approximately 3,500 lf of nearshore aquatic and riparian areas that are designated critical habitat. PCEs at the 13 sites include estuarine and riverine areas for rearing and migration. NMFS CHART (2005b) described existing PCEs within the action area as degraded, with isolated fragments of high quality habitat. In spite of the degraded condition, the CHART report rated the conservation value of the action area as high because it is used as a rearing and migration corridor for all populations of winter-run Chinook salmon and CV spring-run Chinook salmon, and by the largest populations of CV steelhead.

Impacts to PCEs will last for 5 to 15 years. The primary project-related impacts to PCEs are at fall and summer low-flow conditions and result from loss or modification of riparian vegetation, shallow-water habitat, and the increase in bank substrate size. These losses and modifications affect juvenile rearing and migration PCEs by reducing instream cover and refuge areas and food production. The action area serves primarily as a migration corridor. Freshwater migration corridors must function sufficiently to provide adequate passage; project effects are not expected to reduce passage conditions based on the length of time individual juvenile salmonids will be exposed to the reduced quality and availability of refuge areas as they transit through the action area . Thus, NMFS does not expect the 5 to 15 year reduction in the quality and availability of refuge areas in this reach of the river to be limiting to the anadromous populations in the system. From year 15 through 50, the PCEs will improve as vegetation matures and extends over the shoreline. The improved conditions are expected to improve the growth and survival conditions for juvenile fish. Therefore, we do not expect project-related impacts to reduce the conservation value of designated critical habitat of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead.

VIII. CONCLUSION

After reviewing the best available scientific and commercial information, the current status of CV spring-run Chinook salmon, and CV steelhead, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the BALMD PL 84-99 Levee Repairs, as proposed, are not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, or CV steelhead, and are not likely to destroy or adversely modify their designated critical habitat.

After reviewing the best available scientific and commercial information, the current status of the Southern DPS of North American green sturgeon, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' biological opinion that the BALMD PL 84-99 erosion repairs, as proposed, are not likely to jeopardize the continued existence of the Southern DPS of the North American green sturgeon.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS as an act which kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not the purpose of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The listing of the Southern DPS of North American green sturgeon became effective on July 7, 2006, and some or all of the ESA section 9(a) prohibitions against take will become effective upon the future issuance of protective regulations under section 4(d). Because there are no section 9(a) prohibitions at this time, the incidental take statement, as it pertains to the Southern DPS of North American green sturgeon does not become effective until the issuance of a final 4(d) regulation.

The measures described below are non-discretionary, and must be undertaken by the Corps so that they become binding conditions of any grant or permit, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps, by issuing a permit to BALMD, has a continuing duty to regulate the activity covered by this incidental take statement. If BALMD: (1) fails to execute the terms and conditions, or (2) fails to require the contractors to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps or its permittee, BALMD, must report the progress of the action and its impact on the species to NMFS as specified in the incidental take statement (50 CFR §402.14(i)(3)).

A. Amount and Extent of Take

NMFS anticipates incidental take of Sacramento River winter-run Chinook salmon, CV steelhead, CV spring-run Chinook salmon, and the Southern DPS of North American green sturgeon from impacts related to construction, O&M, and through long-term impairment of essential behavior patterns as a result of reductions in the quality or quantity of their habitat. Take is expected to be limited to rearing and smolting juveniles.

NMFS cannot, using the best available information, quantify the anticipated incidental take of individual Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon because of the variability and uncertainty associated with the population size of each species, annual variations in the timing of migration, and uncertainties regarding individual habitat use of the project area. However, it is possible to describe the conditions that will lead to the take.

Accordingly, NMFS is quantifying take of Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon incidental to the action in terms associated with the extent and duration of initial construction and O&M activities, and long-term impacts as indexed by the SAM model. The following level of incidental take from project activities is anticipated:

1. Take of juvenile and smolt Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon in the form of injury and death from predation caused by constructed-related turbidity that extends up to 100 feet from the shoreline, and 1,000 feet downstream, during individual site construction that occurs between the months of February 2007 to mid-May 2007.

2. Take of juvenile and smolt Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, and the Southern DPS of North American green sturgeon, in the form of harm or injury of fish from O&M actions is expected from habitat-related disturbances from the annual placement of approximately 600 cubic yards of material to the extent of the project life (*i.e.*, 50 years). Take will be in the form of harm to the species through modification or degradation of juvenile rearing and migration habitat.

Anticipated incidental take may be exceeded if project activities exceed the criteria described above, if the project is not implemented as described in the BA prepared for this project, or if the project is not implemented in compliance with the terms and conditions of this incidental take statement.

B. Effect of the Take

NMFS has determined that the above level of take is not likely to jeopardize Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, CV steelhead, or the Southern DPS of North American green sturgeon. The effect of this action in the proposed project areas will consist of fish behavior modification, temporary loss of habitat value, and potential death or injury of juvenile Sacramento River winter-run Chinook salmon, CV steelhead, and CV spring-run Chinook salmon, and the Southern DPS of North American green sturgeon.

C. Reasonable and Prudent Measures

NMFS has determined that the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the incidental take of listed anadromous salmonids.

1. Measures shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the life of the project to ensure their effectiveness.

D. Terms and Conditions

1. Measures shall be taken to maintain, monitor, and adaptively manage all conservation measures throughout the life of the project to ensure their effectiveness.

   a. The Corps shall continue to coordinate the implementation of project-specific monitoring as described in *section II, Description of the Proposed Action*, with the IWG agencies.

   b. The Corps shall ensure that future maintenance actions that repair the bank protection structure fully replace conservation features including benches, soil, and riparian vegetation.

Reports and notifications required by these terms and conditions shall be submitted to:

Sacramento Area Office
National Marine Fisheries Service
650 Capitol Mall, Suite 8-300
Sacramento California 95814-4706
FAX: (916) 930-3629
Phone: (916) 930-3600

X. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. These conservation recommendations include discretionary measures that the Corps can implement to avoid or minimize adverse effects of a proposed action on a listed species or critical habitat or regarding the development of information. NMFS provides the following conservation recommendations that would avoid or reduce adverse impacts to listed salmonids:

1. The Corps, under the authority of section 7(a)(1) of the ESA, should implement recovery and recovery plan-based actions within and outside of traditional flood damage reduction projects.

2. The Corps should continue to focus on retaining, restoring and creating river riparian corridors in the recovery of the listed salmonid species within their flood control plan.

3. The Corps should make set-back levees integral components of the Corps' authorized bank protection or ecosystem restoration efforts.

4. The Corps should make more effective use of ecosystem restoration programs, such as those found in sections 1135 and 206 of the respective Water Resource Developments Acts of 1986 and 1996. The section 1135 program seems especially applicable as the depressed baselines of the Sacramento River winter-run Chinook salmon, CV steelhead, and CV spring-run Chinook salmon are, to an appreciable extent, the result of the Corps' SRBPP program.

5. The PL 84-99 authority should not be used to apply rock revetment to sites where only earthen banks existed previously or which suffer from design flaws not related to erosion.

6. The Corps should incorporate the costs of conducting lengthy planning efforts, involved consultations, implementation of proven off-site conservation measures, and maintenance and monitoring requirements associated with riprapping into each project's cost-benefit analysis such that the economic benefits of set-back levees are more accurately expressed to the public and regulatory agencies. This includes a recognition of the economic value of salmonids as a commercial and sport fishing resource.

7. The Corps should conduct or fund studies to identify set-back levee opportunities, at locations where the existing levees are in need of repair or not, where set-back levees could be built now, under the SRBPP, or other appropriate Corps authority. Removal of the existing riprap from the abandoned levee should be investigated in restored sites and anywhere removal does not compromise flood safety.

8. The Corps should begin early intervention bank protection efforts using set-back levees, and biotechnical approaches, which may then preclude later having to use rock fill and/or rock riprap to achieve engineering goals.

9. As recommended in the NMFS Proposed Recovery Plan for the Sacramento River winter-run Chinook Salmon (NMFS 1997), the Corps should preserve and restore riparian habitat and meander belts along the Delta with the following actions: (1) avoid any loss or additional fragmentation of riparian habitat in acreage, lineal

coverage, or habitat value, and provide in-kind mitigation when such losses are unavoidable (*e.g.*, create meander belts along the Sacramento River by levee set-backs), (2) assess riparian habitat along the Sacramento River from Keswick Dam to Chipps island and along Delta waterways within the rearing and migratory corridor of juvenile winter-run Chinook salmon, (3) develop and implement a Sacramento River and Delta Riparian Habitat Restoration and Management Plan (*e.g.*, restore marshlands within the Delta and Suisun Bay), and (4) amend the Sacramento River Flood Control and SRBPP to recognize and ensure the protection of riparian habitat values for fish and wildlife (*e.g.*, develop and implement alternative levee maintenance practices).

10. Section 404 authorities should be used more effectively to prevent the unauthorized application of riprap by private entities.

To be kept informed of actions minimizing or avoiding adverse effects, or benefiting listed or special status species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

XI. REINITIATION OF CONSULTATION

This concludes formal consultation on the BALMD PL 84-99 Levee Repairs. Reinitiation of formal consultation is required if: (1) the amount or extent of taking specified in any incidental take statement is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the action, including the avoidance, minimization, and compensation measures listed in the *Description of the Proposed Action* section is subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion; or (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

XII. LITERATURE CITED

Adams, P.B., Grimes, C.B., Hightower, J.E., Lindley, S.T., and M.L. Moser. 2002. Status review for North American green sturgeon, *Acipenser medirostris*. National Marine Fisheries Service. 58 pages.

Arthur, J.F., M.D. Ball, and S.Y. Baughman. 1996. Summary of Federal and State project environmental impacts in the San Francisco Bay-Delta Estuary, California. In: J.T. Holibaugh (ed.). The San Francisco Bay: the ecosystem. Further investigations into the natural history of San Francisco Bay and Delta with reference to the influence of man. Friesen Printers, Altona, Monitoba.

Bailey, E.D. 1954. Time pattern of 1953–54 migration of salmon and steelhead into the upper Sacramento River. California Department of Fish and Game. Unpublished report.

Bash, J., C. Berman, and S. Bolton. 2001. Effects of turbidity and suspended solids on salmonids. Center for Streamside Studies, University of Washington.

Beamesderfer, R., M. Simpson, G. Kopp, J. Inman, A. Fuller, and D. Demko. 2004. Historical and current information on green sturgeon occurrence in the Sacramento and San Joaquin rivers and tributaries. S.P. Cramer & Associates, Inc. 44 pages.

Bennett, W.A. and P.B. Moyle. 1996. Where have all the fishes gone? Interactive factors producing fish declines in the Sacramento-San Joaquin Estuary. In: J.T. Holibaugh (ed.). The San Francisco Bay: the ecosystem. Further investigations into the natural history of San Francisco Bay and Delta with reference to the influence of man. Friesen Printers, Altona, Monitoba.

Bisson, P.B. and R.E. Bilby. 1982. Avoidance of suspended sediment by juvenile coho salmon. North American Journal of Fisheries Management. 2: 371-374.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19:83-138.

Borthwick, S.M., R.R. Corwin, and C.R. Liston. 1999. Investigations of fish entrainment by archimededs and internal helical pumps at the Red Bluff Research Pumping Plant, Sacramento California: February 1997-June 1998.

Brandes, P.L., and J.S. McLain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. In: Brown, R.L., editor. Contributions to the biology of Central Valley salmonids. Volume 2. California Department of Fish and Game Fish Bulletin 179:39-136.

Brannan-Andrus Levee Maintenance District. 2006. Brannan-Andrus Levee Maintenance District 13 PL84-99 Emergency Repair Sites Sacramento County, California, Biological Assessment. Prepared by Tetra Tech, Inc. Sacramento, California.

Brown, L.R., and J.R. May. 2000. Benthic Macroinvertebrate assemblages and their relations with environmental variables in the Sacramento and San Joaquin drainages, California, 1993-1997. U.S. Geological Survey. Water Resources Investigation Report. 00-4125.

Buell, J.W. 1992. Fish entrainment monitoring of the western-pacific dredge *R W Lofgren* during operations outside the preferred work period. Portland Oregon. 38 pages.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon and California. U.S. Department of Commerce. NOAA Technical Memo. NMFS-NWFSC-27. 261 p.

CALFED. 2000. Ecosystem Restoration Program Plan, Volume II. Technical Appendix to draft PEIS/EIR. July 2000.

CALFED Science Program. 2001. Science in action: scrutinizing the Delta Cross Channel. CALFED Bay-Delta Program. June 2001. http://science.calwater.ca.gov/library.shtml.

CALFED. 2005. Review of the biological opinion of the Long-term Central Valley Project and State Water Project operations Criteria and Plan. Report of the Technical Review Panel. 45 pages.

California Advisory Committee on Salmon and Steelhead. 1988. Restoring the balance. California Department of Fish and Game, Sacramento, California.

California Department of Fish and Game. 1992. Sturgeon in relation to water development in the Sacramento-San Joaquin Estuary. WRINT-CDFG-Exhibit 28.

California Department of Fish and Game. 1995. Adult steelhead counts in Mill and Deer Creeks, Tehama County, October 1993-June 1994. Inland Fisheries Administrative Report Number 95-3.

California Department of Fish and Game. 1998. Report to the Fish and Game Commission. A status review of the spring-run Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River Drainage. Candidate species status report 98-01.

California Department of Fish and Game. 2002. California Department of Fish and Game comments to NMFS regarding green sturgeon listing. 79 p. + app.

California Department of Water Resources. 2003. Bulletin 250-2002: Fish Passage Improvement.

California Department of Water Resources. 2006. Critical Levee Emergency Repair Projects, Draft Biological Assessment. Prepared by URS Corporation. Sacramento, California.

California Resources Agency. 1989. Upper Sacramento River Fisheries and Riparian Management Plan. Prepared by an Advisory Council established by SB1086, authored by State Senator Jim Nielson.

California Regional Water Quality Control Board-Central Valley Region. 1998. Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins, fourth edition. Available at: http://www.swrcb.ca.gov/~CRegionalBoard5/home.html.

Campbell, E.A., and P.B. Moyle. 1992. Effects of temperature, flow, and disturbance on adult spring-run Chinook salmon. University of California. Water Resources Center. Technical Completion Report.

Cannon, T., and T. Kennedy. 2003. Snorkel survey of the lower American River 2003. Draft report prepared for: U.S. Fish and Wildlife Service, Anadromous Fish Restoration Program.

Carlson T.J., G. Ploskey, R.L. Johnson, R.P. Mueller, M.A. Weiland, and P.N. Johnson. 2001. Observations of the behavior and distribution of fish in relation to the Columbia River navigational channel and channel maintenance activities. Prepared for the U.S. Army Corps of Engineers, Portland District, Portland Oregon.

Clark, G. H. 1929. Sacramento-San Joaquin salmon (*Oncorhynchus tshawytscha*) fishery of California. California Fish and Game Bulletin. 17:73.

Cohen, A.N., and P.B. Moyle. 2004. Summary of data and analyses indicating that exotic species have impaired the beneficial uses of certain California waters: a report submitted to the State Water Resources Control Board on June 14, 2004. 25 pages.

Deng, X., J.P. Van Eenennaam, and S.I. Doroshov. 2002. Comparison of early life stages and growth of green and white sturgeon. Transactions of the American Fisheries Society. 28:237-248.

Dettman, D.H., D.W. Kelley, and W.T. Mitchell. 1987. The influence of flow on Central Valley salmon. Prepared for the California Department of Water Resources. Revised July 1987. Available from D.W. Kelley and Associates, 8955 Langs Hill Rd., P.O. Box 634, Newcastle, CA 95658.

Dolloff, C.A. 1993. Predation by river otters (*Lutra Canadensis*) on juvenile coho salmon (*Oncorhynchus kisutch*) and Dolly Varden (*Salvelinus malma*) in southeast Alaska. Canadian Journal of Fisheries and Aquatic Sciences. 50: 312-315.

Emmett, R.L., S.L. Stone, S.A. Hinton, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in West coast estuaries, Volume II: Species life history summaries. ELMR Report No. 8. NOAA/NOS Strategic Environmental Assessments Division, Rockville, Maryland.

Erickson, D.L., J.A. North, J.E. Hightower, J. Weber, and L. Lauck. 2002. Movement and habitat use of green sturgeon *Acipenser medirostris* in the Rogue River, Oregon, USA. Journal of Applied Ichthyology. 18:565-569.

Feist, B.E., J. J. Anderson and R. Miyamoto. 1992. Potential impacts of pile driving on juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon behavior and distribution. FRI-UW-9603. Fisheries Resources Institute, University of Washington, Seattle.

Fisher, F.W. 1994. Past and present status of Central Valley Chinook salmon. Conservation Biology. 8:870-873.

Gaines, P.D., and C.D. Martin. 2002. Abundance and seasonal, spatial, and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Final Report Red Bluff Research Pumping Plant, Report Series: Volume 14. U.S. Fish and Wildlife Service. Red Buff, California.

Gaines, P.D., and W.R. Poytress. 2004. Brood-year 2003 winter Chinook juvenile production indices with comparisons to adult escapement. U.S. Fish and Wildlife Service report to California Bay-Delta Authority. San Francisco, California.

Gard, M. 1995. Upper Sacramento River IFIM study scoping report. U.S. Fish Wildlife Service. 14 pages.

Garland, R.D., K.F. Tiffan, D.W. Rondorf, and L.O. Clark. 2002. Comparison of subyearling fall Chinook salmon's use of riprap revetments and unaltered habitats in Lake Wallula of the Columbia River. North American Journal of Fisheries Management. 22:1283-1289.

Gingras, M. 1997. Mark/recapture experiments at Clifton Court Forebay to estimate pre-screen loss of juvenile fishes: 1976-1993. Interagency Ecological Program Technical Report No. 55.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of Federally listed ESU of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memo. NMFS-NWFSC-66, 598 p.

Hallock, R.J., D.H. Fry, and D.A. LaFaunce. 1957. The use of wire fyke traps to estimate the runs of adult salmon and steelhead in the Sacramento River. California Fish and Game. Volume 43, No. 4, pages 271-298.

Hallock, R.J., W.F. Van Woert, and L. Shapovalov. 1961. An evaluation of stocking hatchery reared steelhead rainbow (*Salmo gairdnerii gairdnerii*) in the Sacramento River system. California Department of Fish and Game Bulletin No. 114.

Hallock, R.J., R.F. Elwell, and D.H. Fry. 1970. Migrations of adult king salmon *Oncorhynchus tshawytscha* in the San Joaquin Delta as demonstrated by the use of sonic tags. California Department of Fish and Game. Fish Bulletin 151.

Hare, S.R., N.J. Mantua, and R.C. Frances. 1999. Inverse production regimes: Alaska and west coast Pacific salmon. Fisheries. 24:6-14.

Healey, M.C. 1980. Utilization of the Nanaimo River Estuary by juvenile Chinook salmon, *Oncorhynchus tshawytscha*. U.S. Fisheries Bulletin. 77:653-668.

Healey, M.C. 1991. Life history of Chinook salmon (*Oncorhynchus tshawytscha*). In: Groot, C., Margolis L., editors. Pacific salmon life-histories. Vancouver: UBC Press. Pages 313-393.

Herren, J.R., and S.S. Kawasaki. 2001. Inventory of water diversions in four geographic areas in California's Central Valley. Pages 343-355. *In:* Contributions to the Biology of Central Valley Salmonids. R.L. Brown, editor. Volume. 2. California Fish and Game. Fish Bulletin 179.

Heublein, J.C., J.T. Kelly, and A.P. Klimley. 2006. Spawning migration and habitat of green sturgeon, *Acipenser medirostris*, in the Sacramento River. Presentation at the CALFED Science Conference, Sacramento California. October 23, 2006.

Huang, B., and Z. Liu. 2000. Temperature Trend of the Last 40 Years in the Upper Pacific Ocean. Journal of Climate. 4:3738–3750.

Hughes, N.F. 2004. The wave-drag hypothesis: an explanation for sized-based lateral segregation during the upstream migration of salmonids. Canadian Journal of Fisheries and Aquatic Sciences. 61:103-109.

Hunter, J. 1959. Survival and production of pink and chum salmon in a coastal stream. Journal of the Fisheries Research Board of Canada. 16:835-886.

Interagency Ecological Program Steelhead Project Work Team. 1999. Monitoring, assessment, and research on Central Valley Steelhead: Status of knowledge, review existing programs, and assessment needs. In Comprehensive Monitoring, Assessment, and Research Program Plan, Technical Appendix VII-11.

Intergovernmental Panel on Climate Change (IPCC) 2001 Climate Change 2001: The scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T.,Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 881 pages.

Israel, J. 2006. North American green sturgeon population characterization and abundance of the Southern DPS. Presentation to NMFS on April 4, 2006.

Jones & Stokes Associates, Inc. 2002. Foundation runs report for restoration action gaming trials. Prepared for Friant Water Users Authority and Natural Resource Defense Council.

Keefer, M.L., C.A. Perry, M.A. Jepson, and L.C. Stuehrenberg. 2004. Upstream migration rates of radio-tagged adult Chinook salmon in riverine habitats of the Columbia River basin. Journal of Fish Biology. 65:1126-1141.

Kelley, J.T., A.P. Klimley, and C.E. Crocker. 2006. Movements of green sturgeon, *Acipenser medirostris*, in the San Francisco Bay Estuary, CA. Editorial manuscript for Environmental Biology of Fishes.

Klimley, A.P. 2002. Biological assessment of green sturgeon in the Sacramento-San Joaquin watershed. A proposal to the California Bay-Delta Authority.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1981. Influences of freshwater inflow on Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin Estuary. *In* R.D. Cross and D.L. Williams (editors), Proceedings of the National Symposium on Freshwater Inflow to Estuaries, pages 88-108. U.S. Fish and Wildlife Service, USFWS/OBS-81-04.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile Chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin estuary, California, pp. 393-411. In: V.S. Kennedy (editor). Estuarine comparisons. Academic Press, New York, New York.

Kjelson, M., B. Loudermilk, D. Hood, and P. Brandes. 1990. The influence of San Joaquin River inflow, Central Valley and State Water Project exports and migration route on fall-run Chinook smolt survival in the Southern Delta during the Spring of 1989. Fisheries Assistance Office, Stockton, California. WQCP-USFWS-4.

Kynard, B., E. Parker, and T. Parker. 2005. Behavior of early life intervals of Klamath River green sturgeon, *Acipenser medirostris*, with note on body color. Environmental Biology of Fishes. 72:85-97.

Lassettre, N.S., and R.R. Harris. 2001. The geomorphic and ecological influence of large woody debris in streams and rivers. University of California. Berkeley.

Levy, D.A., and T.G. Northcote. 1981. The distribution and abundance of juvenile salmon in marsh habitats of the Fraser River Estuary. Westwater Research Centre, University of British Columbia, Technical Report no. 25. Vancouver, B.C., Canada.

LGL Environmental Research Associates. 2006. August 15, 2006, Inseason update on Mill Creek Spring-run Chinook Salmon Hydroacoustic Monitoring project in Tehama County, California. North Bonneville, Washington.

Li, H., C. Schreck, C. Bond, and E. Rexstad. 1987. Factors influencing changes in fish assemblages of Pacific Northwest streams. Pages 193-202 in: W. Matthews and D. Heins, editors. Community and evolutionary ecology of North American stream fishes. University of Oklahoma Press, Norman, Oklahoma.

Lindley, S.T., and M.S. Mohr. 2003. Modeling the effect of striped bass (*Morone saxatillis*) on the population viability of Sacramento River winter-run Chinook salmon *(Oncorhynchus tshawytscha*). Fisheries Bulletin. 101:321-331.

Lindley, S.T., R. Schick, E. Mora, P.B. Adams, J.J. Anderson, S. Greene, C. Hanson, B.P. May, D.R. McEwan, R.B. MacFarlane, C. Swanson, and J.G. Williams. 2006a. Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin basin. In press at San Francisco Estuary and Watershed Science.

Lindley, S.T., R. Schick, A. Agrawal, M. Goslin, T.E. Pearson, E. Mora, J.J. Anderson, B. May, May, S. Greene, C. Hanson, A. Low, D. McEwan, R.B. MacFarlane, C. Swanson, and J.G. Williams. 2006b. Historical population structure of Central Valley steelhead and its alteration by dams. San Francisco Estuary and Watershed Science.

Lindley, S.T. 2006c. Large-scale migrations of green sturgeon. Presentation at Interagency Ecological Program 2006 Annual Workshop, Pacific Grove, California. March 3, 2006.

MacDonald, Lee H., Alan W. Smart, and Robert C. Wissmar. 1991. Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. EPA Region 10 and University of Washington Center for Streamside studies, Seattle, Washington.

MacFarlane, B.R., and E.C. Norton. 2001. Physiological ecology of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) at the southern end of their distribution, the San Francisco Estuary and Gulf of the Farallones, California. Fisheries Bulletin. 100:244-257.

Martin, C.D., P.D. Gaines and R.R. Johnson. 2001. Estimating the abundance of Sacramento River juvenile winter Chinook salmon with comparisons to adult escapement. Red Bluff Research Pumping Plant Report Series, Volume 5. U.S. Fish and Wildlife Service, Red Bluff, California.

Matter, A.L., and B.P. Sandford. 2003. A comparison of migration rates of radio and PIT-tagged adult Snake River Chinook salmon through the Columbia River hydropower system. North American Journal of Fisheries Management. 23:967-973.

McEwan, D.R., and T. Jackson. 1996. Steelhead Restoration and Management Plan for California. California Department of Fish and Game, February 1996.

McEwan, D.R. 2001. Central Valley Steelhead. Contributions to the biology of Central Valley salmonids. R. Brown editor. California Department of Fish and Game Fish Bulletin No 179.

McGill, R.R. Jr. 1987. Land use changes in the Sacramento River riparian zone, Redding to Colusa. A third update: 1982-1987. Department of Water Resources, Northern District.

McLain, J., and G. Castillo. 2006. Nearshore areas used by fry Chinook salmon (*Oncorhynchus tshawytscha*) in the north-western Sacramento-San Joaquin Delta, California. Draft manuscript submitted to San Francisco Estuary Watershed Science.

McLaughlin, L., and J. McLain. 2004. Comparison of relative abundance of adult Chinook salmon (*Oncorhynchus tshawytscha*) in the Delta Cross Channel, Georgiana Slough, and Sacramento River, California 2001. 14 pages.

McMichael, G.A., A.L. Fritts, and T.N. Pearsons. 1998. Electrofishing injury to stream salmonids. California Department of Fish and Game. Sacramento, California. 234 pages.

McReynolds, T.R., Garman, C.E., Ward, P.D., and M.C. Schommer. 2005. Butte and Big Chico Creeks spring-run Chinook salmon, *Oncorhynchus tshawytscha* life history investigation, 2003-2004. California Department of Fish and Game, Inland Fisheries Administrative Report No. 2005-1.

Meehan W.R., and T.C. Bjornn. 1991. Salmonid distribution and life histories. American Fisheries Society Special Publication. 19: 47-82.

Meng, L., P.B. Moyle, and B. Herbold. 1994. Changes in abundance and distribution of native and introduced fishes of Suisun March. Transactions of the American Fisheries Society. 123(4):498-507.

Meng, L., and P.B. Moyle. 1995. Status of splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society. 124(4):538-549.

Meng, L., and S.A. Matern. 2001. Native and introduced larval fishes of Suisun Marsh, California: The effects of freshwater flow. Transactions of the American Fisheries Society. 130(5):750-765.

Meyer, J.H. 1979. A review of the literature on the value of estuarine and shoreline areas to juvenile salmonids in Puget Sound, Washington. U.S. Fish and Wildlife Service. Fisheries Assistance Office, Olympia, Washington.

Michny, F.J., and Deibel, R. 1986. Sacramento River, Chico Landing to Red Bluff Project, 1985 juvenile salmon study. U.S. Fish and Wildlife Service, Sacramento, California.

Michny, F., and M. Hampton. 1984. Sacramento River Chico Landing to Red Bluff Project, 1984 juvenile salmon study. U.S. Fish and Wildlife Service, Division of Ecological Services, Sacramento, California.

Michny, F.J. 1989. Concluding report, evaluation of palisade bank stabilization, Woodson Bridge, Sacramento River, California. US Fish and Wildlife Service, Sacramento, California.

Mora, E. 2006. Modeling green sturgeon habitat in the Central Valley. Presentation at the 2006 CALFED Science conference, October 23, 2006. Sacramento, California.

Mount, J.F. 1995. California rivers and streams: The conflict between fluvial process and land use. University California Press, Berkeley.

Moyle, P. B., J. E. Williams, and E.D. Wikramanayake. 1989. Fish species of special concern of California. Wildlife and Fisheries Biology Department, University of California, Davis. Prepared for The Resources Agency, California Department of Fish and Game, Rancho Cordova.

Moyle, P.B., Foley P.J., and R.M. Yoshiyama. 1992. Status of green sturgeon, *Acipenser medirostris*, in California. Final report sent to NMFS, Terminal Island, CA by UC Davis Department of Wildlife and Fisheries Biology. 12 pages.

Moyle, P.B. 2002. Inland fishes of California. University of California Press, Berkeley.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memo. NMFS-NWFSC-35, 443 p.

Myrick, C.A., and Cech J.J. 2004. Temperature effects on Chinook salmon and steelhead: a review focusing on California's Central Valley populations. Bay-Delta Modeling Forum technical publication 01-1.

Nakamoto, R.J., Kisanuki, T.T., and Goldsmith, G.H. 1995. Age and growth of Klamath River green sturgeon (*Acipenser medirostris*). U.S. Fish and Wildlife Service. Project # 93-FP-13. 20 pages.

National Marine Fisheries Service. 1996. Factors for decline: a supplement to the notice of determination for west coast steelhead under the Endangered Species Act. National Marine Fisheries Service, Protected Resource Division, Portland OR and Long Beach BA.

National Marine Fisheries Service. 1997. NMFS proposed recovery plan for the Sacramento River winter-run Chinook salmon. National Marine Fisheries Service Southwest Region, Long Beach, California. August 1997.

National Marine Fisheries Service. 1998. Factors contributing to the decline of Chinook salmon: An addendum to the 1996 west coast steelhead factors for decline report. Protected Resources Division, National Marine Fisheries Service. Portland Oregon.

National Marine Fisheries Service and California Department of Fish and Game. 2001. Final report on anadromous salmon fish hatcheries in California. Prepared by Joint Hatchery Review Committee. June 27, 2001.

National Marine Fisheries Service. 2003. Updated status of Federally listed ESUs of West Coast salmon and steelhead. Northwest and Southwest Fisheries Science Centers. July 2003.

National Marine Fisheries Service. 2005a. Green sturgeon (*Acipenser medirostris*) status review update, February 2005. Biological review team, Santa Cruz Laboratory, Southwest Fisheries Science Center. 31 pages.

National Marine Fisheries Service. 2005b. Final assessment of the National Marine Fisheries Service's critical habitat analytical review teams (CHARTs) for seven salmon and steelhead evolutionarily significant units (ESUs) in California. Prepared by the NOAA Fisheries Protected Resources Division, Long Beach, California.

National Marine Fisheries Service. 2006. Biological Opinion for the Stockton Deep Water Ship Channel maintenance dredging and levee stabilization project. April 4, 2006.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management. 16:693-727.

Noakes, D.J. 1998. On the coherence of salmon abundance trends and environmental trends. North Pacific Anadromous Fishery Commission Bulletin. pages 454-463.

Nobriga, M., P. Cadrett. 2001. Differences among hatchery and wild steelhead: evidence from Delta fish monitoring programs. Interagency Ecological Program for the San Francisco Estuary Newsletter. 14:3:30-38.

Pacific States Marine Fisheries Commission. 1992. White sturgeon management framework plan. Portland, Oregon.

Patten, B. 1962. Cottid predation upon salmon fry in a Washington stream. Transactions of the American Fisheries Society. 91:427-429.

Patten, B. 1971a. Predation by sculpins on fall Chinook salmon, *Oncorhynchus tshawytscha*, fry of hatchery origin. National Marine Fisheries Service, Special Scientific Report, Fisheries No. 621.

Patten, B. 1971b. Increased predation by the torrent sculpin, *Cottus rhotheus*, on coho salmon fry, *Oncorhynchus kisutch*, during moonlight nights. Journal of the Fisheries Research Board of Canada. 28:1352-1354.

Peterson, J.H. and J.F. Kitchell. 2001. Climate regimes and water temperature changes in the Columbia River: Bioenergetic implications for predators of juvenile salmon. Canadian Journal of Fisheries and Aquatic Sciences. 58:1831-1841.

Phillips, R.W., and H.J. Campbell. 1961. The embryonic survival of coho salmon and steelhead trout as influenced by some environmental conditions in gravel beds. Annual Report to Pacific Marine Fisheries Commission. 14:60-73.

Pickard, A., A. Grover, and F. Hall. 1982. An evaluation of predator composition at three locations on the Sacramento River. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary. Technical Report No. 2, 20 pages.

Piegay, H. 2002. Dynamics of wood in large rivers, in Gregory, S.V. (ed.), Ecology and management of wood in world rivers. American Fisheries Society. Bethesda, Maryland.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1979. Methods for evaluating stream, riparian, and biotic conditions. USDA General Technical Report INT-138. Ogden, Utah.

Power, M.E. 1987. Predator avoidance by grazing fishes in temperate and tropical streams: importance of stream depth and prey size. In: Kerfoot W.C. and Sih A. (eds.) Predation: direct and indirect impacts on aquatic communities. University Press of New England.

Reynolds, F.L., T.J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley streams: a plan for action. California Department of Fish and Game, Inland Fisheries Division, Sacramento.

Ross, Sarah. 2006. December 12, 2006, monitoring report: riparian mitigation on the Lower American River. Powerpoint presentation.

Schaffter, R. 1980. Fish occurrence, size, and distribution in the Sacramento River near Hood, California during 1973 and 1974. California Department of Fish and Game.

Schaffter, R. 1997. White sturgeon spawning migrations and location of spawning habitat in the Sacramento River, California. California Department of Fish and Game. 83:1-20.

Schlosser, I.J. 1991. Stream fish ecology: A landscape perspective. BioScience 41:704-711.

Schmetterling, D.A., C.G. Clancy, and T.M. Brandt. 2001. Effects of riprap bank reinforcement on stream salmonids in the Western United States. Fisheries. 26:8-13.

Shapovalov, L., and A.C. Taft. 1954. The live histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. California Department of Fish and Game, Fish Bulletin. 98.

Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelhead and coho salmon. Transactions of the American Fisheries Society 113:142-150.

Sillman, A.J., A.K. Beach, D.A. Dahlin, and E.R. Loew. 2005. Photoreceptors and visual pigments in the retina of the fully anadromous green sturgeon (*Acipenser medirostris*) and the potamodromous pallid sturgeon (*Scaphirhynchus albus*). Journal of Comparative Physiology. 191:799-811.

Slater, D.W. 1963. Winter-run Chinook salmon in the Sacramento River, California with notes on water temperature requirements at spawning. Special Science Report No. 461.

Snider, B., and R.G. Titus. 2000. Timing, composition, and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing, October 1996-September 1997. California Department of Fish and Game, Habitat Conservation Division, Stream Evaluation Program Technical Report No. 00-04.

Spence, B., G. Lomnicky, R., Hughes, and R. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. Technical Environmental Research Services Corp., Corvallis, Oregon.

S.P. Crammer and Associates, Inc. 2001. Stanislaus River data report. Oakdale CA.

Sommer, T.R., M.L. Nobriga, W.C. Harrel, W. Batham, and W.J. Kimmerer. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences. 58:325-333.

S.P. Cramer and Associates, Inc. 2000. Stanislaus River data report. Oakdale CA.

Stachowicz, J. J., J. R. Terwin, R. B. Whitlatch, and R. W. Osman. 2002. Linking climate change and biological invasions: Ocean warming facilitates non-indigenous species invasions. PNAS, November 26, 2002. 99:15497–15500.

Stephenson, A.E. and D.E. Fast. 2005. Monitoring and evaluation of avian predation on juvenile salmonids on the Yakima River, Washington. Annual Report 2004. March 2005.

Stevens, D.E. 1961. Food habits of striped bass, *Roccus saxitilis* (Walbaum), in the Rio Vista area of the Sacramento River. Master's Thesis, University of California, Berkeley.

Stevens, D.E. and L.W. Miller. 1983. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin river system. North American Journal of Fisheries Management. 3:425-437.

Stillwater Sciences. 2002. Merced River corridor restoration plan. Stillwater Sciences, Berkeley, California. 245 pages.

Stillwater Sciences. 2004. Appendix H: conceptual models of focus fish species response to selected habitat variables. In: Sacramento River Bank Protection final Standard Assessment Methodology. July 2004.

Stillwater Sciences. 2006. Biological Assessment for five critical erosion sites, river miles: 26.9 left, 34.5 right, 72.2 right, 99.3 right, and 123.5 left. Sacramento River Bank Protection Project. May 12, 2006.

Sweeney, B.W., Bott, T.L., Jackson, J.K., Kaplan, L.A., Newbold, J.D., Standley, L.J., Hession, W.C., and R.J. Horwitz. 2004. Riparian deforestation, stream narrowing, and loss of stream ecosystem services. National Academy of Sciences. 101:14132-14137.

Tetra Tech, Inc. 2006. Evaluation of the Brannan-Andrus Levee Maintenance District 13 PL 84-99 Emergency Repair Sites Using the Statndard Assessment Method. Sacramento County, California. 14 pages plus appendices.

Tucker, M.E., C.M. Williams, and R.R. Johnson. 1998. Abundance, food habits, and life history aspects of Sacramento squawfish and striped bass at the Red Bluff Diversion Complex, including the research pumping plant, Sacramento River, California: 1994 to 1996. Red Bluff Research Pumping Plant Report Services, Vol. 4. USFWS, Red Bluff, California. 54 pages.

Tucker, M.E., C.D. Martin, and P.D. Gaines. 2003. Spatial and temporal distributions of Sacramento pikeminnow and striped bass at the Red Bluff Diversion Complex, including the research pumping plant, Sacramento River, California: January, 1997 to August, 1998. Red Bluff Research Pumping Plant Report Services, Vol. 10. USFWS, Red Bluff, California. 32 pages.

U.S. Army Corps of Engineers Sacramento District. 2004. Standard Assessment Methodology for the Sacramento River Bank Protection Project, Final. Prepared by Stillwater Sciences and Dean Ryan Consultants, Sacramento, California. Contract DACW05-99-D-0006. Task Order 0017. 25 May.

U.S. Fish and Wildlife Service. 1995. Working paper: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group, Stockton, California.

U.S. Fish and Wildlife Service. 1997. Abundance and survival of juvenile Chinook salmon in the Sacramento-San Joaquin Estuary. 1994 Annual Progress Report. Stockton, California.

U.S. Fish and Wildlife Service. 2000. Impacts of riprapping to ecosystem functioning, lower Sacramento River, California. U.S. Fish and Wildlife Service, Sacramento Field Office, Sacramento, California. Prepared for US Army Corps of Engineers, Sacramento District.

U.S. Fish and Wildlife Service. 2001. Abundance and Survival of Juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary: 1997 and 1998. Annual progress report Sacramento-San Joaquin Estuary.

U.S. Fish and Wildlife Service. 2002. Spawning areas of green sturgeon *Acipenser medirostris* in the upper Sacramento River California. U.S. Fish and Wildlife Service, Red Bluff, CA.

Van Eenennaam, J.P., M.A.H. Webb, X. Deng, and S.I. Doroshov. 2001. Artificial Spawning and Larval Rearing of Klamath River Green Sturgeon. Transactions of the American Fisheries Society. 130: 159-165.

Vogel, D.A., and K.R. Marine. 1991. Guide to Upper Sacramento River Chinook salmon life history. Prepared for the U.S. Bureau of Reclamation, Central Valley Project.

Vogel, D.A. 2004. Juvenile Chinook salmon radio-telemetry studies in the Northern and Central Sacramento-San Joaquin Delta, 2002-2003. January 2004.

Waite, I.R., and R.A. Barnhart. 1992. Habitat criteria for rearing steelhead: a comparison of site-specific and standard curves for use in the instream flow incremental methodology. North American Journal of Fisheries Management. 12:40-46.

Waples, R.S. 1991. Pacific Salmon, *Oncorhynchus spp*., and the definition of "species" under the Endangered Species Act. Marine Fisheries Review. 53:11-21.

Ward, P.D., McReynolds, T.R., and C.E. Garman. 2002. Butte and Big Chico Creeks spring-run Chinook salmon, *Oncorhynchus tshawytscha* life history investigation, 2000-2001. California Department of Fish and Game, Inland Fisheries Administrative Report.

Ward, P.D., McReynolds, T.R., and C.E. Garman. 2003. Butte and Big Chico Creeks spring-run Chinook salmon, *Oncorhynchus tshawytscha* life history investigation, 2001-2002. California Department of Fish and Game, Inland Fisheries Administrative Report.

Yoshiyama, R.M., E.R. Gerstung, F.W. Fisher, and P.B Moyle. 1996. Historical and present distribution of Chinook salmon in the Central Valley Drainage of California. In: Sierra Nevada Ecosystem Project, Final Report to Congress, volume III, Assessments, Commissioned Reports, and Background Information (University of California, Davis, Centers for Water and Wildland Resources, 1996).

Yoshiyama, R.M., F.W. Fisher, and P.B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley region of California. North American Journal of Fisheries Management 18:487-521.

Yoshiyama, R.M, E.R. Gerstung, F.W. Fisher, and P.B. Moyle. 2001. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. In: Brown, R.L., editor. Contributions to the biology of Central Valley salmonids. Volume 1. California Department of Fish and Game Fish Bulletin 179:71-177.

Enclosure 2

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION AND RECOMMENDATIONS

ACTION AGENCY:	United States Army Corps of Engineers Sacramento District
ACTIVITY:	Brannan-Andrus Levee Maintenance District, 13 PL 84-99 Levee Repairs
CONSULTATION CONDUCTED BY:	NOAA's National Marine Fisheries Service, Southwest Region
FILE NUMBER:	151422SWR2005SA00659
DATE ISSUED:	

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

This document represents the National Marine Fisheries Service's (NMFS) Essential Fish Habitat (EFH) consultation based on our review of information provided by the U.S. Army Corps of Engineers (Corps) on the proposed Brannan-Andrus Levee Maintenance District (BALMD) 13 Public Law (PL) 84-99 Levee Repairs, Sacramento County, California. The Magnuson-Stevens Fishery Conservation Act (MSA) as amended (U.S.C 180 et seq.) requires that EFH be identified and described in Federal fishery management plans. Federal action agencies must consult with NMFS on activities which they fund, permit, or carry out that may adversely affect EFH. NMFS is required to provide EFH conservation and enhancement recommendations to the Federal action agencies. The geographic extent of freshwater EFH for Pacific salmon in the Sacramento River includes waters currently or historically accessible to salmon within the Sacramento River.

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle.

The biological opinion for the BALMD 13 PL 84-99 Levee Repairs addresses Chinook salmon listed under the both the Endangered Species Act (ESA) and the MSA that potentially will be affected by the proposed action. These salmon include Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) and CV spring-run Chinook salmon (*O. tshawytscha)*. This EFH consultation will concentrate on Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) because they are covered under the MSA but not listed under the ESA.

Historically, Central Valley fall-run Chinook salmon generally spawned in the Central Valley and lower-foothill reaches up to an elevation of approximately 1,000 feet. Much of the historical fall-run spawning habitat was located below existing dam sites and the run therefore was not as severely affected by water projects as other runs in the Central Valley.

Although fall-run Chinook salmon abundance is relatively high, several factors continue to affect habitat conditions in the Sacramento River, including loss of fish to unscreened agricultural diversions, predation by warm-water fish species, lack of rearing habitat, regulated river flows, high water temperatures, and reversed flows in the Delta that draw juveniles into State and Federal water project pumps.

A. Life History and Habitat Requirements

Central Valley fall-run Chinook salmon enter the Sacramento River from July through December, and late fall-run enter between October and March. Fall-run Chinook salmon generally spawn from October through December, and late fall-run fish spawn from January to April. The physical characteristics of Chinook salmon spawning beds vary considerably. Chinook salmon will spawn in water that ranges from a few centimeters to several meters deep provided that the there is suitable sub-gravel flow (Healey 1991). Spawning typically occurs in gravel beds that are located in marginally swift riffles, runs and pool tails with water depths exceeding 1 foot and velocities ranging from 1 to 3.5 feet per second. Preferred spawning substrate is clean loose gravel ranging from 1 to 4 inches in diameter with less that 5 percent fines (Reiser and Bjornn 1979).

Fall-run Chinook salmon eggs incubate between October and March, and juvenile rearing and smolt emigration occur from January through June (Reynolds *et al.* 1993). Shortly after emergence, most fry disperse downstream towards the Sacramento-San Joaquin Delta and estuary while finding refuge in shallow waters with bank cover formed by tree roots, logs, and submerged or overhead vegetation (Kjelson *et al.* 1982). These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Smolts generally spend a very short time in the Delta and estuary before entry into the ocean.

II. PROPOSED ACTION

The Corps proposes to issue a permit to BALMD to repair 13 sites in the Sacramento River Delta. The proposed action is described in the *Description of the Proposed Action* section of the preceding biological opinion (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on Pacific Coast salmon EFH would be similar to those discussed in the *Effects of the Proposed Action* section of the preceding biological opinion (Enclosure 1) for endangered Sacramento River winter-run Chinook salmon, threatened CV spring-run Chinook salmon, and threatened CV steelhead. A summary of the effects of the proposed action on Central Valley fall-/late fall-run Chinook salmon are discussed below.

Adverse effects to Chinook salmon habitat will result from construction related impacts, operations and maintenance impacts, and long-term impacts related to modification of aquatic and riparian habitat at the 13 project sites. Primary construction related impacts include riprapping approximately 3,500 linear feet of riverbank. Integrated conservation measures to minimize adverse effects of riprapping will be applied to all sites. Conservation measures include construction of seasonally inundated terraces that will be planted with riparian vegetation.

In-channel construction activities such as vegetation removal, grouting, and rock placement will cause increased levels of turbidity. Turbidity will be minimized by implementing the proposed conservation measures such as implementation of best management practices (BMPs) and adherence to Regional Board water quality standards. Fuel spills or use of toxic compounds during project construction could release toxic contaminants into the Sacramento River. Adherence to BMPs that dictate the use, containment, and cleanup of contaminants will minimize the risk of introducing such products to the waterway because the prevention and contingency measures will require frequent equipment checks to prevent leaks, will keep stockpiled materials away from the water, and will require that absorbent booms are kept on-site to prevent petroleum products from entering the river in the event of a spill or leak.

The effects of operation and maintenance (O&M) actions will be similar to construction impacts. O&M actions will not occur every year, and actions will be specific and localized in nature, O&M impacts will be smaller and shorter in duration.

At some sites, there will be short and long-term losses of habitat value. Long-term impacts are expected to adversely affect EFH for adult salmon at average fall and summer water surface elevation for the life of the project. However, at winter and spring water surface elevations, adverse effects to EFH will be short-term, lasting from 1 to 5 years. Long-term effects of the project (*i.e.*, 5 to 50 years) will be positive as riparian habitat becomes mature. Overall, the action will result in a net increase in habitat conditions for Chinook salmon that essential to their survival and growth, especially at winter and spring flows when the majority of fish are outmigrating through the action area. This net increase is expected to maintain and improve the conservation value of the habitat for Chinook salmon and avoid habitat fragmentation that typically is associated with riprapping.

IV. CONCLUSION

Upon review of the effects of BALMD PL 84-99 13 Levee Reparis, NMFS believes that the project will result in adverse effects to the EFH of Pacific salmon protected under the MSA.

V. EFH CONSERVATION RECOMMENDATIONS

Considering that the habitat requirements of fall-run within the action area are similar to the Federally listed species addressed in the preceding biological opinion (Enclosure 1), NMFS recommends that Terms and Condition 1a through 1d; as well as all the Conservation Recommendations in the preceding biological opinion prepared for the Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead ESUs be adopted as EFH Conservation Recommendations.

Section 305(b)4(B) of the MSA requires the Corps to provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the Corps for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR 600.920[j]). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

IV. LITERATURE CITED

BALMD. 2006. Project Information Report for PL 84-99 Levee Rehabilitation.

Healey, M.C. 1991. Life history of Chinook salmon. *In* C. Groot and L. Margolis: Pacific Salmon Life Histories. University of British Columbia Press. pp. 213-393.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin estuary, California, pp. 393-411. *In*: V.S. Kennedy (ed.). Estuarine comparisons. Academic Press, New York, NY.

Lister, D.B., and H.S. Genoe. 1970. Stream habitat utilization by cohabiting underyearlings of (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon in the Big Qualicum River, British Columbia. J. Fish. Res. Board Can. 27:1215-1224.

Reiser, D.W., and T.C. Bjornn. 1979. Influence of forest and rangeland management on anadromous fish habitat in western North America: Habitat requirements of anadromous salmonids. U.S. Department of Agriculture, Forest Service General Technical Report PNW-96. Pacific Northwest Forest and Range Experimental Station, Portland, Oregon. 54 pp.

Reynolds, F.L., T.J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley Streams: A Plan for Action. California Department of Fish and Game. Inland Fisheries Division.

Enclosure 2

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT
ESSENTIAL FISH HABITAT CONSULTATION AND RECOMMENDATIONS

ACTION AGENCY:	United States Army Corps of Engineers Sacramento District
ACTIVITY:	Brannan-Andrus Levee Maintenance District, 13 PL 84-99 Levee Repairs
CONSULTATION CONDUCTED BY:	NOAA's National Marine Fisheries Service, Southwest Region
FILE NUMBER:	151422SWR2005SA00659
DATE ISSUED:	February 14, 2007

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

This document represents the National Marine Fisheries Service's (NMFS) Essential Fish Habitat (EFH) consultation based on our review of information provided by the U.S. Army Corps of Engineers (Corps) on the proposed Brannan-Andrus Levee Maintenance District (BALMD) 13 Public Law (PL) 84-99 Levee Repairs, Sacramento County, California. The Magnuson-Stevens Fishery Conservation Act (MSA) as amended (U.S.C 180 et seq.) requires that EFH be identified and described in Federal fishery management plans. Federal action agencies must consult with NMFS on activities which they fund, permit, or carry out that may adversely affect EFH. NMFS is required to provide EFH conservation and enhancement recommendations to the Federal action agencies. The geographic extent of freshwater EFH for Pacific salmon in the Sacramento River includes waters currently or historically accessible to salmon within the Sacramento River.

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle.

The biological opinion for the BALMD 13 PL 84-99 Levee Repairs addresses Chinook salmon listed under the both the Endangered Species Act (ESA) and the MSA that potentially will be affected by the proposed action. These salmon include Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) and CV spring-run Chinook salmon (*O. tshawytscha*). This EFH consultation will concentrate on Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) because they are covered under the MSA but not listed under the ESA.

Historically, Central Valley fall-run Chinook salmon generally spawned in the Central Valley and lower-foothill reaches up to an elevation of approximately 1,000 feet. Much of the historical fall-run spawning habitat was located below existing dam sites and the run therefore was not as severely affected by water projects as other runs in the Central Valley.

Although fall-run Chinook salmon abundance is relatively high, several factors continue to affect habitat conditions in the Sacramento River, including loss of fish to unscreened agricultural diversions, predation by warm-water fish species, lack of rearing habitat, regulated river flows, high water temperatures, and reversed flows in the Delta that draw juveniles into State and Federal water project pumps.

A. Life History and Habitat Requirements

Central Valley fall-run Chinook salmon enter the Sacramento River from July through December, and late fall-run enter between October and March. Fall-run Chinook salmon generally spawn from October through December, and late fall-run fish spawn from January to April. The physical characteristics of Chinook salmon spawning beds vary considerably. Chinook salmon will spawn in water that ranges from a few centimeters to several meters deep provided that the there is suitable sub-gravel flow (Healey 1991). Spawning typically occurs in gravel beds that are located in marginally swift riffles, runs and pool tails with water depths exceeding 1 foot and velocities ranging from 1 to 3.5 feet per second. Preferred spawning substrate is clean loose gravel ranging from 1 to 4 inches in diameter with less that 5 percent fines (Reiser and Bjornn 1979).

Fall-run Chinook salmon eggs incubate between October and March, and juvenile rearing and smolt emigration occur from January through June (Reynolds *et al.* 1993). Shortly after emergence, most fry disperse downstream towards the Sacramento-San Joaquin Delta and estuary while finding refuge in shallow waters with bank cover formed by tree roots, logs, and submerged or overhead vegetation (Kjelson *et al.* 1982). These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Smolts generally spend a very short time in the Delta and estuary before entry into the ocean.

II. PROPOSED ACTION

The Corps proposes to issue a permit to BALMD to repair 13 sites in the Sacramento River Delta. The proposed action is described in the *Description of the Proposed Action* section of the preceding biological opinion (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on Pacific Coast salmon EFH would be similar to those discussed in the *Effects of the Proposed Action* section of the preceding biological opinion (Enclosure 1) for endangered Sacramento River winter-run Chinook salmon, threatened CV spring-run Chinook salmon, and threatened CV steelhead. A summary of the effects of the proposed action on Central Valley fall-/late fall-run Chinook salmon are discussed below.

Adverse effects to Chinook salmon habitat will result from construction related impacts, operations and maintenance impacts, and long-term impacts related to modification of aquatic and riparian habitat at the 13 project sites. Primary construction related impacts include riprapping approximately 3,500 linear feet of riverbank. Integrated conservation measures to minimize adverse effects of riprapping will be applied to all sites. Conservation measures include construction of seasonally inundated terraces that will be planted with riparian vegetation.

In-channel construction activities such as vegetation removal, grouting, and rock placement will cause increased levels of turbidity. Turbidity will be minimized by implementing the proposed conservation measures such as implementation of best management practices (BMPs) and adherence to Regional Board water quality standards. Fuel spills or use of toxic compounds during project construction could release toxic contaminants into the Sacramento River. Adherence to BMPs that dictate the use, containment, and cleanup of contaminants will minimize the risk of introducing such products to the waterway because the prevention and contingency measures will require frequent equipment checks to prevent leaks, will keep stockpiled materials away from the water, and will require that absorbent booms are kept on-site to prevent petroleum products from entering the river in the event of a spill or leak.

The effects of operation and maintenance (O&M) actions will be similar to construction impacts. O&M actions will not occur every year, and actions will be specific and localized in nature, O&M impacts will be smaller and shorter in duration.

At some sites, there will be short and long-term losses of habitat value. Long-term impacts are expected to adversely affect EFH for adult salmon at average fall and summer water surface elevation for the life of the project. However, at winter and spring water surface elevations, adverse effects to EFH will be short-term, lasting from 1 to 5 years. Long-term effects of the project (*i.e.*, 5 to 50 years) will be positive as riparian habitat becomes mature. Overall, the action will result in a net increase in habitat conditions for Chinook salmon that essential to their survival and growth, especially at winter and spring flows when the majority of fish are outmigrating through the action area. This net increase is expected to maintain and improve the conservation value of the habitat for Chinook salmon and avoid habitat fragmentation that typically is associated with riprapping.

IV. CONCLUSION

Upon review of the effects of BALMD PL 84-99 13 Levee Reparis, NMFS believes that the project will result in adverse effects to the EFH of Pacific salmon protected under the MSA.

V. EFH CONSERVATION RECOMMENDATIONS

Considering that the habitat requirements of fall-run within the action area are similar to the Federally listed species addressed in the preceding biological opinion (Enclosure 1), NMFS recommends that Terms and Condition 1a through 1d; as well as all the Conservation Recommendations in the preceding biological opinion prepared for the Sacramento River winter-run Chinook salmon, CV spring-run Chinook salmon, and CV steelhead ESUs be adopted as EFH Conservation Recommendations.

Section 305(b)4(B) of the MSA requires the Corps to provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the Corps for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR 600.920[j]). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

IV. LITERATURE CITED

BALMD. 2006. Project Information Report for PL 84-99 Levee Rehabilitation.

Healey, M.C. 1991. Life history of Chinook salmon. *In* C. Groot and L. Margolis: Pacific Salmon Life Histories. University of British Columbia Press. pp. 213-393.

Kjelson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin estuary, California, pp. 393-411. *In*: V.S. Kennedy (ed.). Estuarine comparisons. Academic Press, New York, NY.

Lister, D.B., and H.S. Genoe. 1970. Stream habitat utilization by cohabiting underyearlings of (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon in the Big Qualicum River, British Columbia. J. Fish. Res. Board Can. 27:1215-1224.

Reiser, D.W., and T.C. Bjornn. 1979. Influence of forest and rangeland management on anadromous fish habitat in western North America: Habitat requirements of anadromous salmonids. U.S. Department of Agriculture, Forest Service General Technical Report PNW-96. Pacific Northwest Forest and Range Experimental Station, Portland, Oregon. 54 pp.

Reynolds, F.L., T.J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley Streams: A Plan for Action. California Department of Fish and Game. Inland Fisheries Division.